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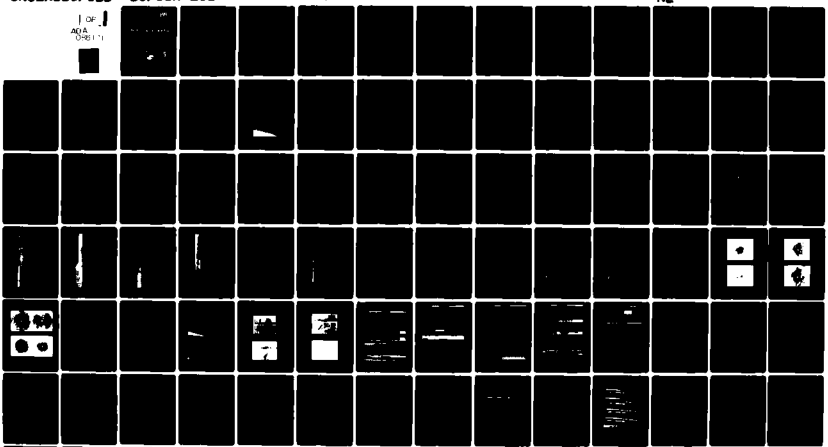

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TRACALS EVALUATION REPORT

INITIAL EVALUATION REPORT

AIRPORT SURVEILLANCE AND PRECISION APPROACH RADAR (AN/GPN-24)

Nellis AFB, Nevada

(80/66R-208)

10 December 1979 to 6 March 1980

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DEPARTMENT OF THE AIR FORCE
1866 Facility Checking Squadron
Scott AFB, Illinois

16 May 1980

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Nellis AFB, Nevada

(80/66R-208)

10 December 1979 to 6 March 1980

Prepared by:

JAMES R. MINSTERL, Capt, USAF
Radar Evaluation Team Chief

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Commander

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AN/GPN-22	AN/GPN-20	
AN/GSN-12	AN/TPX-42	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report presents data collected from ~~10 December 1979 to 6 March 1980~~ to define the capabilities and limitations of the radar facility at Nellis AFB, Nevada. This report includes descriptions of the useable radar coverage and tracking capabilities, analysis of all flight and equipment performance data, and the performance predictions for the system. The data presented can be used as a guide for anticipated equipment performance until there is an addition, deletion, or relocation of equipment, or until a significant change occurs in the horizontal profile.

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GLOSSARY

ABPCU	Antenna Beam Position Control Unit
AFCC	Air Force Communications Command
AGL	Above Ground Level
AOC	Automatic Overload Control
ASR	Airport Surveillance Radar
ATC	Air Traffic Control
ATCRBS	Air Traffic Control Radar Beacon System
ATS	Average Target Strength
BSR	Blip-Scan Ratio
CFA	Crossed Field Amplifier
CP	Circular Polarization
CPU	Central Processing Unit
dB	Decibel
dBm	Decibel Referenced to 1 Milliwatt
DMTI	Digital Moving Target Indicator
FAA	Federal Aviation Administration
FCS	Facility Checking Squadron
FTC	Fast Time Constant
GTC	Gain Time Control
Hz	Hertz
IAW	In Accordance With
IFR	Instrument Flight Rules
LP	Linear Polarization
MDS	Minimum Discernible Signal
MHz	Megahertz
MSL	Mean Sea Level
MTI	Moving Target Indicator
MVA	Minimum Vectoring Altitude
NM	Nautical Mile
PAR	Precision Approach Radar
PPI	Plan Position Indicator
PRF	Pulse Repetition Frequency
RABM	Range Azimuth Beacon Monitor
RCI	Radar Coverage Indicator
RF	Radio Frequency
RSC	Radar Set Control
SCV	Subclutter Visibility
STAR	Second-Time-Around Rejection
STC	Sensitivity Time Control
TDC	Target Data Computer
TO	Technical Order
TRACALS	Traffic Control and Landing Systems
TSDA	Transfer Switch Drawer Assembly
TWT	Traveling Wave Tube
usec	Microsecond
VFR	Visual Flight Rules
VSP	Video Signal Processor
VSWR	Voltage Standing-Wave Ratio

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FIGURE

TABLES

ATTACHMENTS

1. SUMMARY

1-1. Evaluation Profile. This evaluation was conducted to define the capabilities and limitations of the AN/GPN-24 facility at Nellis AFB, Nevada in its installed environment. The evaluation was conducted in conjunction with an installation effort for the purpose of commissioning. This evaluation includes a comprehensive examination of equipment parameters, siting criteria, and operational performance of the AN/GPN-24 facilities, and establishes the optimum system configuration.

1-2. ASR:

a. Equipment Performance. Equipment checks were performed in accordance with technical orders and current evaluation procedures. All equipment parameters were within technical order specifications.

b. Evaluation Results. The optimum antenna tilt is 2.0° mechanical, which yields an electromagnetic (true) tilt of 4.05°. Although multipath propagation did cause holes in the radar coverage, the holes were generally beyond 20 NM.

c. Capabilities. The Nellis ASR is capable of performing its assigned ATC mission. Radar coverage extends to approximately 13 NM at 1000 feet AGL; 25 NM at 3000 feet AGL; 40 NM at 5000 feet AGL; 39 NM at 7000 feet AGL; 52 NM at 10,000 feet AGL; and 60 NM at 25,000 feet AGL. These ranges are valid when tracking a C-140 size aircraft, using CP, MTI, and the passive antenna and MTI gated as shown in Attachment A11-1/2.

d. Limitations. Coverage within the ranges stated in paragraph 1-2c may be reduced by nulling, SCV, screening, MTI blind speeds, and weather. The coverage of the radar may be affected due to ground reflections since the reflected wave may arrive at a target in a phase relationship which will either oppose or aid the direct wave. The algebraic addition of the reflected wave and the direct wave creates a radar coverage area where areas of minimum power, called nulls, and maximum power, called lobes, exist. Nulling causes intermittent loss of targets beyond 20 NM at all altitudes. Screening (see Attachment A3-1/4) by the mountainous terrain surrounding Nellis limits coverage below 10,000 feet. This is due to the 2.0° average screening surrounding Nellis AFB. Attachment A6-1 indicates those areas where the radar is screened at the MVA. Tangential MTI blind speeds cause a loss of the aircraft target anytime the aircraft is flying a course perpendicular to the ASR antenna within the MTI gated area. Additionally, ranges are decreased or increased by refractive weather conditions.

1-3. ATCRBS.

a. Equipment Performance. Initial checks revealed the VSWR was unreadable. A bad transmission line connector was identified and repaired. The equipment operated satisfactorily during the flight evaluation.

b. Evaluation Results. The minimum operating power is 100 watts measured at J-5 on the back of the TSDA. Coverage consistently extended beyond the primary radar range at every altitude.

c. Capabilities. The ATCRBS is fully capable of performing its

assigned ATC mission.

d. Limitations. False targets due to reflections appeared during the evaluation. They were primarily due to hangars east of the facilities and a blast fence southeast of the ASR. Multipath propagation can cause intermittent loss of ATCRBS returns throughout the ATC mission area. Additionally, screening will affect ATCRBS range as it affects ASR.

1-4. PAR:

a. Siting. The airfield survey was performed to verify the information required in calculating the values which are entered into the site parameter panel for each runway. The site parameter panel originally contained data for runways 03R and 03L, the required values for runways 21L and 21R were determined and entered. Additionally, the location representing the midpoint between the touchdown points for runways 21R and 21L was marked for installation of a MTI reflector.

b. Equipment Performance. A scan receiver module was replaced due to initial low MDS readings. Several tape load errors were experienced because of problems with the tape reader. A field alignment of the tape read station was attempted with good results, but it is recommended that the tape unit be replaced.

c. Evaluation Results. The published glide path angle of 3.0° was flown for the four runways, 03R, 03L, 21R and 21L. The respective angles measured were 3.04°, 3.10°, 2.93° and 2.90° for the primary Operational Program tape, and 3.01°, 3.07°, 2.99° and 2.98° for the backup Operational Program tape. Due to equipment failure, noncoherent MTI was not flight checked for approaches to runways 21L and 21R for either operational tape and for approaches to runways 03L and 03R for the backup tape.

d. Capabilities. The AN/GPN-22 is capable of performing its assigned mission at Nellis AFB, Nevada. It is capable of detecting and tracking F-5 size or larger aircraft at 14 NM in either coherent or noncoherent MTI mode of display. This detection range is based upon using the normal vertical beam scan for approaches to runways 21L and 21R and using a modified vertical beam scan for approaches to runways 03L and 03R.

e. Limitations. Second-time-around clutter returns on approaches to runways 03L and 03R necessitated changing the -1.0° to +7.0° vertical beam scan to +1.5° to +7.0°. Without this change, aircraft detection and tracking is extremely limited due to intense second-time-around clutter. Between 5-10 NM on approaches to runways 03L and 03R the clutter environment due to primary and secondary returns limits the track receiver's ability to lock-on targets. The capabilities stated in paragraph 1-4d may be affected by weather (see Appendix V, paragraph 1c(2)). Intense superrefractive and trapping conditions along the ground surface will intensify both primary and second-time-around clutter returns.

1-5. Power Systems. The primary power system is fully capable of providing service to the AN/GPN-24 radar system. Backup power to the AN/GPN-20 ASR

and AN/GSN-12 shelter was satisfactory. The AN/GPN-22 PAR backup power generator voltage output dropped whenever the air conditioner came on line resulting in an automatic shutdown of the PAR. Therefore, the backup power is not considered adequate or reliable for the AN/GPN-22.

2. RECOMMENDATIONS

2-1. ASR:

a. The following system configuration should be used.

(1) Antenna Tilt. The optimum antenna tilt is 2.0° mechanical which yields a true tilt of 4.05° (see Appendix III, para 4c(6)).

(2) Polarization. LP should be used for normal operations. CP should be used when weather conditions dictate. During adverse weather, the tracking quality of CP will result in reduced tracking quality at all altitudes (see Appendix III, para 4f(2)).

(3) PRF. Staggered PRF should be used continuously (see Appendix III, para 4d(2)).

(4) MTI. The MTI should be gated as shown in Attachment A11-1. During periods of superrefractive or trapping conditions, the MTI can be manually gated to encompass the abnormal increase in ground clutter (see Appendix III, para 4a(2)(a)).

(5) Video Enhancer. The MTI and Normal enhancers should be used at all times. During ASR approaches the MTI enhancer should be off to prevent the center of target error induced by the enhancer (see Appendix III, para 4f(1)(a)).

(6) Normal Log Video/MTI Log Video. When weather or EMI conditions exist, the log video feature will help eliminate interference.

(7) Passive Antenna. The passive antenna should be gated as shown in Attachment A11-2 (see Appendix III, para 4f(5)).

(8) STC. The STC should be set to STC-1 for everyday operation (see Appendix III, para 4f(4)).

(9) Receiver Gain. The receiver gain should be set to MAX (1).

b. Air Traffic Controllers should work closely with local weather personnel to identify subrefractive, superrefractive and trapping conditions and to understand the limitations of the radar when these conditions exist (see Appendix III, para 1c(2)).

2-2. ATCRBS. The following system configuration should be used.

a. Power. The output power should be 100 watts as measured at J-5 at the back of the TSDA (see Appendix IV, para 4d).

b. GTC. The GTC should be on (see Appendix IV, para 4c(2)) and aligned as specified IAW TO 31P4-2TPX-42-2.

c. VSP. The VSP switches should be set as follows (see Attachment A17-2).

(1) Window size: 10

(2) Window lead edge: 2

(3) Window Trail Edge: 1

(4) Confidence count: 3

(5) P-mode/All-mode switch position: All

(6) Delta switch position: +2

(7) Azimuth offset count: 19

(8) PRF switch position: <380

c. Defruiter. The defruiter should be used (see Appendix IV, para 4e).

2-3. <u>PAR</u>:

a. The following configuration should be used for day-to-day operation:

(1) Normal/MTI Operation. Either coherent or noncoherent MTI must be used as clutter returns make tracking of aircraft impossible in Normal (Appendix V, para 4a).

(2) PAR Performance. PAR performance 1 should be selected for tracking F-4 size or larger aircraft within 4 NM (Appendix V, para 4c(2)).

(3) Acquisition Gain High/Low. In high power Acquisition Gain Low should be used at the option of the individual controller (Appendix V, para 4c(3)).

(4) STAR. This feature should be utilized with a setting of 1 (Appendix V, para 4c(4)(b)).

(5) Baseline Clipping. This feature should not be used as it reduces receiver sensitivity (Appendix V, para 4c(5)(b)).

(6) High/Low Power. The low power mode must be used as high power results in multipath propagation which causes the track receiver to break lock (Appendix V, para 4c(6)(b)).

(7) FTC. Use of this feature is at the discretion of the individual controller (Appendix V, para 4c(7)).

b. The noncoherent MTI mode should be repaired and the approaches to all runways flight checked during the next periodic or special flight check. Both the primary and backup Operational Program tapes should be flight checked.

c. The backup Operational Program computer tape should be used on a daily basis while the primary Operational Program tape should be used as the backup tape.

2-4. Power Systems. The AN/GPN-22 backup power generator operation is incapable of providing adequate and reliable power and should be refered to base civil engineering for further study and resolution (see Appendix VI, para 3).

3. PERFORMANCE PREDICTIONS

3-1. ASR.

(1) An RCI was used to predict the maximum range capability at particular altitudes. As can be seen in Attachment A23-2, the predicted maximum ranges for a C-140 size aircraft at 6500 feet above the radar antenna focal point is 47 NM. The average measured ranges for LP tracks conducted at this selected altitude were 47 NM.

(2) Experience has shown a properly operating ASR will track aircraft very near RCI predictions unless affected by AP, nulling or screening. Attachment A23-1 outlines the use of the RCI, and Attachments A23-2 and A23-3 are RCI's for the active and passive beam patterns set at the true tilt of the ASR. Attachments A23-4 and A23-5 are the RCIs for the active and passive beam patterns set at the true tilt using dual channel operation. The RCI can be used to analyze trends in radar performance. Based upon the RCI performance during the evaluation, correlation between actual and predicted maximum ranges will depend on the aircraft altitude and size. The measured maximum range will vary from the predicted range due to screening and nulling. A list of various aircraft radar reflectivities can be found in Attachment A23-6. An F-5 aircraft at 8400 feet MSL should be tracked to 41 NM on the 045° radial. Using this aircraft and altitude periodic checks can point out trends which may reveal radar degradation not visible to the controllers by other means.

3-2. ATCRBS. All ATCRBS returns exceeded the primary radar returns. Periodic loss of secondary returns due to screening and nulling will occur throughout the Nellis mission area.

3-3. PAR. The PAR is capable of detecting and tracking F-5 size aircraft 14 NM and C-140 size or larger aircraft at 18 NM to touchdown on all approaches. For Approaches to runways 21R and 21L, there were no problems in the track receivers acquiring and locking on the targets. For approaches to runways 03R and 03L, lock-on and tracking of aircraft is satisfactory providing acquisition occurred outside 10 NM or within 5 NM. However, the clutter environment (primary and second-time-around returns) between 5 and 10 NM limits the ability of the track receivers to lock-on and track aircraft in this area.

APPENDIX 1

GENERAL INFORMATION

1. Facility Data:

a. General:

Location: Nellis AFB, Nevada
Communications Area: Tactical Communications Area
Unit: 2069 Communications Squadron (AFCC)
Evaluation Period: 10 December 1979 to 6 March 1980

b. ASR:

Equipment: AN/GPN-20, SN 2
Coordinates: 36° 13' 41.55" N Latitude
115° 03' 20.55" W Longitude
Ground Elevation at radar unit: 1839 feet MSL
Elevation at focal point: 1864 feet MSL

c. ATCRBS:

Equipment: AN/TPX-42A (V), Type III, SN 085
Coordinates: Collocated with ASR
Elevation at focal point: 1871 feet MSL

d. PAR:

Equipment: AN/GPN-22, SN 18
Coordinates: 36° 14' 10.12" N Latitude
115° 02' 01.07" W Longitude
Ground Elevation at radar unit: 1843 feet MSL

2. Runway Data. The primary instrument runway is 21 R.

3. Mission Area. Nellis GCA has no delegated airspace.

4. Mission Responsibilities. Nellis GCA provides precision radar approaches to Nellis AFB.

5. Primary Using Agency/Aircraft Supported. The primary using agency is the 57th Fighter Interceptor Wing. Aircraft normally controlled include the F-4, F-5, F-15, A-10, T-38 and numerous other type aircraft of the United States Air Force, Canadian Air Force, and the Royal Air Force.

6. ATC Facilities. The ATC system consists of an AN/GPN-24 with the AN/TPX-42 and AN/GPA-131 video mapper, a VFR control tower, a TACAN located on the field, and the Las Vegas VORTAC located 10.3 NM south of Nellis AFB.

7. Logistical Support. Logistical and PMEL support is provided by the host base organization.

APPENDIX II

KEY PERSONNEL

1. Ground Evaluation Personnel:

Capt J.R. Minsterl - Team Chief
Capt B.J. Merwald - Electrical Engineer
MSgt N.H. Benner - ATC Radar Evaluation Superintendent
MSgt J.L. Eberle - Air Traffic Controller
TSgt L.G. Bryant - ATC Radar Evaluation Technician
TSgt M.E. Fisher - ATC Radar Evaluation Technician
TSgt G.R. Hurd - ATC Radar Evaluation Technician
TSgt R.F. Innis - ATC Radar Evaluation Technician
SSgt T.W. Zeigler - ATC Radar Evaluation Technician
TSgt G.R. Picha - Geodetic Surveyor
TSgt R.T. Buddemeyer - Geodetic Surveyor

2. Tactical Communications Area Personnel:

Mr. C. Ford - TACCA Representative

3. Southern Communications Area:

Mr. J. Haynes - Scheme Engineer

4. Airborne Evaluation Personnel:

Maj J.R. Barrett - Aircraft Commander
Capt R.H. Woolley - Aircraft Commander
Maj Alexander - 1st Pilot
Capt J.E. Lawrence - 1st Pilot
Capt G.T. Jenkins - 1st Pilot
MSgt F.H. Hutchison Jr - Flight Mechanic
TSgt L.E. Kiracofe - Flight Mechanic
TSgt M.J. Aufieri - Flight Inspection Technician
TSgt S.D. Kennedy - Flight Inspection Technician

5. Facility Personnel Contacted:

Lt Col A.A. Wiegand - Commander
Maj S.A. Tudor - Chief of Maintenance
Capt F.B. Arnemann - Chief, ATC Operations
MSgt W.L. Preston - AN/GPN-24 Transition Project NCO
MSgt C.J. Short - GCA Chief Controller
TSgt J.I. Rackley - NCOIC, Radar Maintenance
SSgt J. Eastrom - Radar Maintenance Technician

APPENDIX III

AIRPORT SURVEILLANCE RADAR (AN/GPN-20)

1. <u>System Description</u>:

a. General. The AN/GPN-20 is a solid state, dual channel, S-band (2700-2900 MHz) surveillance radar system that employs digital processing.

(1) AN/GPN-20. The AN/GPN-20 radar set is used to detect aircraft within 60 nautical miles of the antenna and to provide a corresponding video output for display on a PPI. The dual diversity configuration of the transmitter/receiver pairs provide the system with the capability of operating both channels simultaneously using the common antenna. Operating the two channels in dual diversity provides for enhanced target detection and greater reliability.

(a) Antenna System. RF energy is transmitted and received via an ASR-8 antenna system. The ASR-8 antenna incorporates a dual feedhorn system, that is, a passive (receive only) and an active (transmit and receive) feedhorn. The passive feedhorn is used for short ranges with the active feedhorn used at longer ranges.

(b) Transmitter System. Each transmitter uses air cooled, AFC controlled, tunable magnetrons. A four-pulse staggered PRF mode is employed for virtual elimination of MTI blind speeds.

(c) Receiver System. The receiver system includes a low noise parametric amplifier which provides a minimum RF signal gain of 15 dB. Subsequent to the preamplifier, the receiver is divided into three signal paths: Normal, MTI, and log FTC. The MTI employs a single canceller, dual canceller, or dual canceller with feedback (25 dB, 30 dB, 35 dB, and 40 dB selectable). The MTI module supplies an I (in-phase) video and a Q (quadrature) video signal to the processor unit. Receiver gain and STC are placed in the RF section prior to the parametric amplifier. Special filters are built into the RF section to prevent spurious signals from interfering with receiver operation.

(d) Processor Section. The function of the processor system is to process the Normal, Log FTC, and MTI videos into digitized and analog signals. MTI cancellation occurs in the processor along with weather background video processing. A video enhancer is used to increase the signal-to-noise ratio and eliminate nonsynchronous interference.

(2) Ancillary Equipment.

(a) AN/GSN-12. The GCA equipment consist of an AN/GSN-12, Type I, HI-PAR shelter, housing the OD-129/G data Display Group.

<u>1</u>. OD-130/G Indicator Group. The shelter houses three OD-130/G PPIs used to provide synthetic target writing capabilities in azimuth and range for the ATCRBS in addition to real time video.

<u>2</u>. 980B Computer. The 980B computer consists of a 24K memory, memory controller, CPU, and DMAC capable of processing digital

numerical beacon information from the beacon interrogator and distributes timing and display information to each of the display consoles.

3. AN/GPA-131 Video Mapping Group. The video mapper is a solid state device with five map channels which may be independantly selected at each display position. The video mapper is used to provide air traffic controllers with references to previously established geographic and/or navigational points.

b. Facility Equipment.

(1) Radar Set: AN/GPN-21, SN 925002

(2) Antenna Type: ASR-8, SN 925002

(3) GCA Shelter: AN/GSN-12, SN 001

(4) Video Mapper: AN/GPA-131, SN 094

c. Environmental Factors.

(1) Siting Characteristics. Nellis AFB is located approximately 10 NM northwest of Las Vegas, NV (see Attachment A1-1). The ASR site is located on the southwest corner of the approach end to runway 03L. The area immediately surrounding the ASR is comprised of flat terrain with patches of desert vegatation. The terrain slopes gradually from the northeast to the southwest and will cause slight differences in nulling predictions. The base is surrounded by mountainous terrain which limits radar coverage due to the average screen of 2°. Very little screening is caused by man made objects (see Attachment A3-1/4).

(2) Weather

(a) Refractivity. The theory of refractivity is covered in Attachment A22-1/2. For Nellis AFB, an upper air propagation analysis was done using radiosonde data from a nearby facility. This analysis revealed the possibility of supperrefractive and trapping layers in the valleys of the mountainous terrain near Nellis AFB. A trapping layer can cause radar energy to be trapped below it and thus the radar energy will propagate over extended ranges (see Figure 3-1).

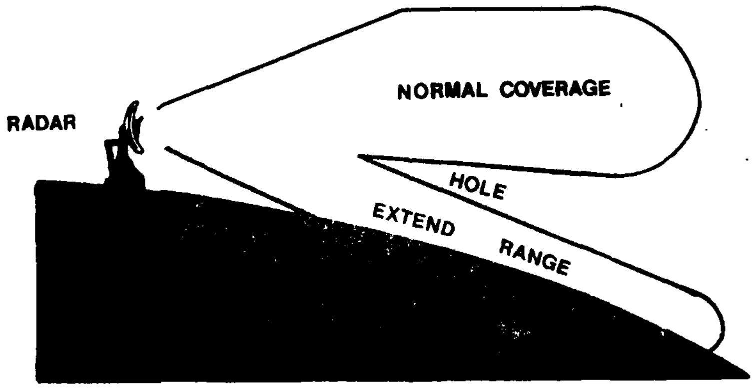


Figure 3-1
Weather Trapping Effects on ASR Coverage

The resultant effect on ASR coverage is threefold. First, below the trapping layer, outer range tracking capability is extended. Second, there is a hole directly above this area. Finally, if radar energy is trapped near the surface, clutter intensity will increase and clutter will exist on the indicator at extended ranges. Since trapping and superrefractive conditions often will exist over the mountains near Nellis AFB, the controllers should be thoroughly familiar with their effects on ASR coverage.

(b) Evaluation Weather Conditions. Superrefractive conditions existed during the early morning hours during the evaluation. This was verified by observing the extended clutter presentation on the indicator. By mid to late morning the propagation appeared normal. However, the propagation conditions in the valleys could not be verified and caused some low altitude extended coverage.

(3) EMI. Some EMI was observed during the evaluation. These were most prevalent to the north of the facility. This condition should be noted to all controllers.

2. Equipment Status. Equipment checks were performed in accordance with existing technical orders and current evaluation procedures. Results of these checks are presented in Attachment A14-1/5. Pre and post flight equipment checks were conducted to ensure the radar equipment was stable and at or above minimum operating standards during the flight phase (see Attachment A20-1).

a. Antenna System:

(1) Solar data indicated the electromagnetic tilt to be 2.05° above the indicated mechanical tilt of the antenna assembly (see Attachment A15-1/2). Solar data was also used to verify proper alignment of the antenna azimuth ring assembly. The azimuth bullring was corrected after solar data revealed a 4° west error.

(2) Unless otherwise indicated, all references to antenna tilt throughout this report refer to the indicated mechanical tilt of the antenna system.

b. Transmitter/Receiver Systems. Channel A magnetron was replaced due to magnetron arcing. No further problems were encountered on either channel.

c. Video Mapper. The video mapper was checked using current evaluation procedures. Video mapper equipment performance was satisfactory (see Attachment A16-1).

3. Evaluation Overview. The overall objective of this evaluation was to determine the capabilities, limitations and optimum configuration of the AN/GPN-20 in its installed environment at Nellis AFB. One of the best ways to measure radar performance is to track a known target and compare the results to theoretical prediction. However, before tracking a known target, the equipment must be eliminated as a source of significant variations in performance. Therefore, the evaluation consisted of two phases: a ground phase and a flight phase. Specific objectives and methods followed to meet those objectives are explained in the following paragraphs.

a. Ground Phase:

(1) To ensure equipment performance had no adverse effect on the evaluation results, extensive equipment checks were performed to verify system parameters met technical order specifications.

(2) To document the environmental effects on ASR coverage, an airfield survey and horizontal screening survey were performed and data on terrain features, EMI and weather conditions were collected.

(3) To determine the electromagnetic (true) antenna tilt and azimuth ring alignment using the solar method, know positions of the sun were compared with receiver voltage peaks as the antenna was manually turned across the sun's position. The highest voltage peaks indicate the sun is traversing the main lobe of the antenna beam pattern. This point is the electromagnetic or true tilt of the antenna comparing the true tilt with the mechanical tilt reading results in the tilt error. At the same time, azimuth readings on the bullring were taken at the voltage peaks for comparison with the known sun positions.

(4) To document the clutter environment at various ASR antenna tilts and to determine which tilts to evaluate during the flight phase, the indicator presentation was photographed with various amounts of RF attenuation inserted at the parametric amplifier, and a detailed analysis of the results was performed.

(5) To ensure proper equipment performance during the flight phase, pre and post flight equipment checks were performed (see Attachment A20-1).

b. Flight Phase. The second phase consisted of sorties were flown with C-140 flight inspection aircraft to evaluate radar performance. The flight phase objectives are stated in the following paragraphs.

(1) To determine the optimum tilt, the aircraft was flown at 8400 feet MSL on the 045° radial and at 12,500 feet MSL on the 255° radial from the Nellis TACAN. The tilts checked were 1.0°, 1.5°, 2.0° and 2.5°. The maximum/minimum range and tracking quality of each antenna tilt was measured. The optimum tilt was then determined by compromising between the clutter intensity, maximum and minimum range capabilities, severity of nulling holes, and tracking quality as measured by ATS and BSR (see Attachments A21-1/3).

(2) To establish the optimum tilt, a flight inspection IAW AFM 55-8 was performed.

(3) To document the vertial profile of the antenna beam pattern, the aircraft was flown at selected altitudes along the 045° radial from the Nellis TACAN.

c. Equipment Configuration. Unless otherwise noted, all flight data were collected with the following ASR configurations: CP, stagger PRF On, MTI range azimuth gate to 22 NM on 045° radial and to 37.5 NM on 255° radial (see Attachment A11-1), STC-1 selected, and receiver gain at MAX.

4. Analysis of Evaluation:

a. Radar Coverage Limitations. Holes in radar coverage (loss of targets for three or more consecutive scans) and maximum range irregularities are generally caused by multipath propagation, weather, MTI blind speeds, SCV limitations of the MTI receiver, screening , or aircraft attitude changes.

(1) Multipath Propagation. This phenomenon is caused by radar energy striking the earth's surface and reflecting upward. This reflected energy combines with the direct energy at the target and either weakens (reflected wave is out of phase with the direct wave) or strengthens (reflected wave is in phase with the direct wave) the return signal. As a result, angles of minimum power (null angles) and angles of maximum power (lobe angles) appear in the vertical coverage pattern. Nulls can cause radar holes, and maximum range can be increased or decreased, depending upon the positioning of the lobes and nulls (see Attachments A7-1/2).

(2) MTI:

(a) An inherent limitation of phase detected MTI systems is the MTI blind speed. The MTI system will cancel aircraft target returns that have an apparent (radial) velocity to the antenna equal or close ($\pm$10 knots) to the system blind speed or any whole multiple thereof. Targets are also cancelled when the aircraft is flying tangential to the antenna because the MTI system sees these targets as having zero velocity. Tangential is the point where an aircraft ground track is perpendicular to the antenna. A system feature that effectively eliminates the blind speed notches, except the tangential notch, is stagger PRF. Stagger PRF should be used to improve the tracking quality of the MTI system. It should be emphasized MTI tangential blind speeds can occur anywhere within the MTI gated area when the aircraft is flying perpendicular to the antenna.

(b) A second limitation to MTI tracking capability is the system SCV. A clutter return signal strength that exceeds aircraft return signal strength by more than 25 dB will cause target loss where the aircraft is traversing that block of clutter. Because this limitation results from a clutter to aircraft return signal ratio, the existence and size of radar holes depends largely on the strength of the aircraft return. Aircraft with relatively large return signals, such as the C-141, will not be affected as much as small aircraft, such as the F-5.

(c) A third limitation of MTI operation is caused by antenna scan modulation. This appears on the indicator as feedthrough within the MTI gated area over clutter. The surfaces of the clutter area are normally rough and jagged and cause the radar returns from the clutter to appear as moving targets to the MTI receiver. Attempts to cancel or remove this feedthrough by methods other than VRS Modes (selectable on the AN/GPN-20 processor cabinet) can greatly degrade MTI performance. It should be noted, scan modulation (clutter feedthrough) is a normal occurrence and is usually not severe enough at Nellis to require the use of VRS modes.

(d) Another limitation to MTI tracking quality is angel clutter and is usually observed during late evening or sunrise hours. Angel clutter, inversion layers and numerous other phonomenon, appear as clutter "dots" which when

viewed closely, appear to be random slow moving targets. The extent of angel clutter will vary by season. When it is extreme enough to limit MTI tracking capability, an appropriate VRS mode should be selected. If the VRS modes have no effect on the angel clutter or another STC setting does not have an effect (see paragraph 4f(4)(a)), and there is a suspected flying hazard controlling aircraft within the clutter, conventional control should be utilized.

(e) Some of the above MTI limitations (blind speeds are the exception) may be reduced by using one of the four VRS modes. This gives the MTI system various responses to slow moving targets. The 40 dB mode will reduce the effects of faster moving targets better than the 25 dB mode. Additionally, the higher VRS modes will increase the size of the tangential notches. Examples of the types of slow moving targets that can be cancelled by the use of this feature include slow moving automobile traffic, scan modulation, and angel clutter.

(3) Aircraft Attitude. The aircraft radar cross-section varies as the aircraft attitude changes. This variation is unpredictable and could cause random loss of radar targets anywhere in the radar coverage area.

b. Equipment Performance. All equipment operated satisfactorily throughout the flight phase and was ruled out as a cause of radar coverage degradation.

c. Optimum Tilt Determination:

(1) The antenna tilt is optimum when the lowest tilt is found satisfying the following conditions:

(a) Clutter strength does not cause inadequate tracking within the MTI gated area due to subclutter visibility limitations.

(b) Range and altitude coverage is adequate to meet operational requirements.

(c) Nulling holes are not significant enough to affect the required coverage area.

(d) Tracking quality is best without reducing the first three requirements.

(2) Clutter intensity photographs were taken for mechanical antenna tilts of 1.0^{o}, 1.5^{o}, 2.0^{o}, and 2.5^{o}. Attachment A9-1 shows the normal clutter presentation.

(3) The annular subclutter visibility photographs are a relative measure of MTI system operation. Signal pulses approximately equal to the return signals of a C-140 aircraft at various ranges are injected into the system. As clutter strength increases, the clutter to signal power increases. If the clutter is strong enough, this ratio becomes larger than the SCV of the MTI receiver and the target is not visible on the indicator. As can be seen in Attachment A10-2, the passive antenna annulars have smaller SCV "holes". This is due to the less intense clutter returns into the receiver. As can be seen in Attachment A10-1, the SCV "holes" become larger as the antenna tilt was lowered.

(4) The tilt determination tracks were flown at 2.5°, 2.0°, 1.5° and 1.0°. Tracking and coverage data are contained in Attachments A21-2/3.

(5) When all tilt determination data were compared, the following conclusions were drawn:

(a) The 2.5° tilt coverage did not extend to the screened range. All other tilts coverage extended to the screened range.

(b) The ATS and BSR tracks on the flight check radial were highest for the 1.5° tilt. However, the ATS and BSR were highest on the 2.0° tilt on the clutter radial.

(6) Since the enhancer could be used to enhance strength "1" targets and the system SCV would not change, the 2.0° mechanical tilt is considered the optimum tilt.

d. Vertical Profile. Attachment A21-4 contains the measured vertical profile and Attachment A21-5 is representative of the coverage capabilities of the ASR system when tracking a C-140 aircraft in CP. These capabilities and limitations are discussed in the following paragraphs.

(1) The inner fringe tracking capability is limited by the cone-of-silence area which is a characteristic of all ASR's. Cone-of-silence (loss of radar coverage) occurs when an aircraft is flying above the antenna where vertical coverage of the antenna beam is limited. The cone-of-silence of the AN/GPN-20 is very narrow due to the passive antenna. Inner fringe coverage at 15,000 ft AGL was 3 NM as compared to the AN/GPN-12 where the inner fringe at 15,000 ft AGL is normally 5 NM.

(2) Stagger PRF was used to virtually eliminate MTI blind speed effects within the MTI gated area shown in Attachment A11-1.

(3) Since clutter saturation did not pose a problem on the flight check radial (045°), SCV limitation was ruled out as a cause for loss of radar contact.

(4) The maximum useable outer range tracking capability extended to 13 NM at 1000 feet AGL, the predicted range. At 3000 feet AGL, coverage extended to 25 NM, 1 NM shorter than predicted. Coverage extended to 40 NM at 5000 feet AGL, 1 NM further than predicted. At 7000 feet AGL coverage extended to 39 NM, approximately 3 NM shorter than predicted. At 10,000 feet AGL, coverage extended to 52 NM, 5 NM farther than predicted. Finally, at 25,000 feet AGL coverage extended to 60 NM, the predicted range (see Attachment A21-4). This coverage was affected by screening and multipath propagation as discussed in the following paragraphs.

(a) In paragraph 4a, radar coverage limitations are defined. Specifically, multipath propagation can either weaken or strengthen a return signal from a target and therefore appear in the vertical coverage pattern. The predicted null locations (see Attachments A7-1/2) as calculated using the FAA Terminal Radar Siting Handbook are compared to the actual null locations in Table 3-1. The predicted nulls correlate closely to actual measured holes. Loss of radar contact and the outer ranges were affected by multipath propagation.

Because of the unpredictable nature of radar cross-section and the lack of visual evidence on the indicator of superrefractive trapping conditions, multipath propagation is the primary cause of holes in the ASR vertical profile.

TABLE 3-1
NULLING ANALYSIS

Altitude feet AGL	Predicted Range (NM)	Measured Range (NM)
3,000	20	20
5,000	25	28
7,000	25	25-28
"	29	31
"	35	37
10,000	36	38
"	43	42
"	49	46

e. Horizontal Coverage:

(1) The vertical profile analyzed in the previous paragraphs can be expanded to define the total horizontal coverage capability by using the environmental data collected during the evaluation. Attachment A5-1/2 shows coverage limitations due to screening.

(2) Another important measure of horizontal coverage capability is the "adequate and reliable" coverage range. According to AFM 55-8 only isolated or nonrecurring misses (not to exceed misses on three or more consecutive scans) occur within this range. Within the maximum usable outer ranges mentioned previusly, adequate and reliable coverage extends to approximately the ranges identifed in Table 3-2. The Table is derived using data obtained from coverage on the 045^{o} radial in conjunction with screening data throughout 360^{o} of coverage.

TABLE 3-2
ADEQUATE AND RELIABLE COVERAGE

RADIAL (DEG)	1000'	2000'	3000' ALTITUDE (AGL)	5000'	7000'	10,000'
00-040	6	10	15	20	30	38
040-070	12	20	20	25	30	38
070-135	4	8	10	15	25	30
135-155	12	20	20	25	30	38
155-180	10	15	20	25	30	38
180-210	12	18	20	25	30	38
210-270	7	10	15	20	30	38
270-305	7	12	18	25	30	38
305-360	5	7	10	15	20	30
			MAX RANGE (NM)			

f. Feature Comparison:

(1) Video Enhancer:

(a) The enhancer improved the tracking quality better than 5%. This was calculated by comparing tracks flown with and without the enhancer on at 6500 feet AGL, and comparing the ATS and BSR. The BSR improved by more than 8%. Although maximum range was not affected (due to screening), the radar holes were reduced. Due to this improvement the video enhancer should be used at all times except during ASR approaches (see para 4f(1)(b)).

(b) Generally, air traffic controllers are hesitant to use the video enhancer due to the stretching of the displayed target. This stretching shifts the displayed center of the target. Since an FAA regulation (FAA 7110.65, para 321a) calls for controllers to use the center of the primary target, an inherent error results when using enhanced video. When the enhancer is in use, all aircraft targets will incur similar displacements. Due to this displacement, the MTI enhancer should not be used when controlling aircraft on ASR approaches.

(2) Polarization. CP reduces clutter from certain weather phenomena and increases the controller's ability to track aircraft through those conditions, while LP is intended for VFR weather. Data gathered comparing LP and CP (see Attachments A21-6/7) show very little difference in average ATS and BSR or range. Weather clutter returns from storm clouds observed on the scope in LP were removed in CP, indicating the polarizer was working correctly.

(3) Dual Diversity. The dual channel feature improved tracking quality better than 10%. This was calculated by comparing tracks flown in dual diversity and single channel operation in LP. BSR improved by 17%. Maximum range was the predicted range and showed no significant improvement due to screening.

(4) STC:

(a) STC provides increasing attenuation to radar returns as range decreases. The use of STC prevents large targets at close range from saturating the receiver (blooming effect) while allowing full gain presentation of distant targets. Additionally, STC reduces the effects of scan modulation and angel clutter present at close range.

(b) MTI STC was used throughout the flight phase; however, no noticeable effects were observed on the inner fringe coverage at any altitude.

(5) Passive Antenna. The passive antenna beam feature was evaluated on the clutter radial. This feature improved tracking quality by 11%. BSR improved 10% on this radial.

(6) When the passive antenna and video enhancer features were combined, the tracking quality improved better than 28%. The BSR improved better than 36%. There were no unusable targets on the clutter radial.

g. ASR Approaches. Excellent tracking was achieved on all ASR approaches to runways 03/21.

h. Video Mapper. The accuracy of the 10 NM video map was satisfactory. All other maps were unsatisfactory.

APPENDIX IV

AIR TRAFFIC CONTROL RADAR BEACON SYSTEM (AN/TPX-42A)

1. System Description:

a. General. The AN/TPX-42 interrogator uses digital techniques to provide numeric and symbolic displays of aircraft position, identity, altitude, emergency, communications failure, and hi-jack. The equipment is divided into four major sections; antenna system, interrogator group, signal processing group, and indicator system. The system also uses a separate monitor/test system, the AN/TPX-49.

b. Special. The Nellis AN/TPX-42 is used in conjunction with the AN/GSN-12 GCA shelter. This shelter uses the 980b computer instead of the IDP to process ATCRBS targets for use on the indicator.

c. Facility Equipment:

(1) Interrogator Set: AN/TPX-42(V) Type III, SN 085

(2) Antenna: GPA-123 Radome, SN 103

d. Environmental Factors:

(1) Siting Characteristics:

(a) Location. The system is collocated with the AN/GPN-20. The ATCRBS antenna is mounted on top of the ASR antenna.

(b) Reflective Sources. There is a large blast-fence to the southeast of the ASR that acts as a reflective surface to the ATCRBS interrogations, causing numerous false targets, i.e. beacon replies appearing at false azimuths and ranges. The false target areas and their probable sources are shown in Attachment A12-1. False targets are further explained in paragraph 4c.

(c) Weather. The weather conditions mentioned in Appendix III, para 1c(2) also apply to the ATCRBS evaluation.

2. Equipment Status. During the ground phase, the ATCRBS was checked using appropriate technical orders and current evaluation procedures. Results of these checks are presented in Attachments A17-1/3. Pre and post flight equipment checks indicated that equipment operation remained within specifications during the flight evaluation (see Attachment A20-1). Results of the ATCRBS system checks follow.

a. During the initial checks, VSWR was unreadable. The connector pins at both ends of the transmission line were found to be bad. The pins were repaired, and the VSWR was rechecked at 1.22:1

b. Supporting Test Equipment. No problems were experienced with the test equipment.

3. Evaluation Overview. The evaluation consisted of two phases: a ground phase and a flight phase. The objectives and methods followed to meet those objectives are explained in the following paragraphs.

a. Ground Phase:

(1) To ensure equipment performance had no adverse effects on the evaluation results, extensive equipment checks were performed to verify the ATCRBS met the operational parameters established by technical order specifications.

(2) To determine the low power mode transmitter power outputs to be evaluated during the flight phase.

(3) To ensure the equipment maintained acceptable performance during the flight phase, pre and post flight equipment checks were performed.

(4) To ensure the ATCRBS antenna beam pattern and the SLS pulse were acceptable, the P-1/3 and P-2 pulses were measured at the RABM antenna while manually rotating the AN/TPX-42 antenna. A spectrum analyzer was attached to the RABM antenna to plot P-1/3 and P-2 signal strength.

b. Flight Phase. The flight phase was accomplished by monitoring the ATCRBS replies from the C-140 flight inspection aircraft throughout the ASR flight phase and by monitoring targets of opportunity. The flight phase objectives and related actions are stated below.

(1) To evaluate the effectiveness of the GTC curve in reducing ring around and false targets, aircraft replies were observed with the GTC on and off.

(2) To find the lowest transmitter power output required to cover the Nellis AFB control area, aircraft replies were scored while using selected power outputs determined during the ground phase.

(3) To ensure ATCRBS coverage adequately satisfied the operational requirements of the Nellis AFB operation area, aircraft replies were scored during the ASR vertical profile.

4. Analysis of Evaluation:

a. Vertical Profile. ATCRBS coverage extended beyond the radar coverage at every altitude flowr Even though no holes were observed in the ATCRBS coverage, loss of targets may occur and can be attributed to one or more of the following causes: transponder lock-out, reply rate limiting, aircraft antenna systems, or multipath propagation.

(1) Transmitter Lock-out. This is a characteristic of the aircraft transponder which is more noticable in areas where more than one station is interrogating the aircraft simultaneously. As the aircraft can only respond to one interrogation at a time, all others are locked out of its receiver. This occurs for the duration of the coded reply transmission, plus an additional period of not more than 125 microseconds.

(2) Reply Rate Limiting. This too is a characteristic of the aircraft transponder which occurs in areas containing numerous ATCRBS. An AOC in the aircraft transponder protects the transmitter section from overloading by reducing reply density based upon received signal strength. AOC levels in the transponder are normally set to 1200 replies per second. Above this level, receiver sensitivity is reduced to discriminate again interrogations from weaker sources. The AOC system enables the transponder to reduce replies due to low level side lobes, reflections, and the more distant stations.

(3) Aircraft Antenna System. Replies can be lost because the aircraft fuselage, wings, or landing gear shield the antenna. This usually occurs when the aircraft is climbing, descending, changing aspect, or maneuvering for landing. To prevent reply loss due to antenna shielding, some aircraft incorporate dual antennas, one located in front of the aircraft and at the rear. If an aircraft is between the chosen antenna and the radar station, interrogations to the transponder could be blocked and no reply will be transmitted.

(4) Multipath Propagation. Multipath propagation in the ATCRBS system occurs under the same general conditions as the ASR system (see Appendix III, para 4a(1)). For the predicted null locations see Attachment A8-1.

b. Mode/Code Processing. Mode/Code processing was monitored throughout the evaluation. In all cases, the mode/code presentation was correct.

c. False Targets:

(1) False targets due to reflection appear when the interrogation main beam energy bounces off a reflective object and thus interrogates the aircraft via a reflected path. The aircraft reply usually follows the same path and is received by the main beam of the antenna. Thus, the aircraft reply is displayed on the PPI at the azimuth of the reflective surface and a greater range than the true target. False targets due to reflections occurred occasionally during the evaluation on the radials depicted in Attachment A12-1. Air Traffic Controllers should be aware of the location of false targets at Nellis AFB.

(2) False targets can also appear when the aircraft transponder replies even though the aircraft is outside the main energy beam, causing what has come to be known as "ring-around". Ring-around was observed when the GTC was turned off and the aircraft was at close range (within 2 NM). With the GTC on, the ring-around was eliminated.

d. IAW TO 31P4-2TPX42-6WC-1, the transmit power was adjusted to determine the lowest output power for the required coverage (60 NM). The power settings of 100 and 200 watts at J-5 on the back of the TSDA were checked during the flight phase. Because of the operational area controlled by the Nellis GCA, the 100 watt setting was determined to be the optimum operating power for the AN/TPX-42.

e. Defruiter. The purpose of the defruiter is to eliminate asynchronous replies (aircraft replies from interrogations by surrounding ATCRBS facilities). No asynchronous replies appeared at any time during the evaluation. The defruiter should be used to eliminate the possibility of asynchronous replies.

f. Antenna Beam Pattern. A spectrum analyzer was used to plot the radiation pattern of the AN/GPA-123 ATCRBS antenna. The main lobe and side lobes were plotted and data analyzed for abnormalities. The main lobe was 4.5° wide at the 3 dB points and none of the sidelobes exceeded the P2 reference level.

APPENDIX V

High Power Precision Approach Radar (AN/GPN-22)

1. System Description:

a. General. The AN/GPN-22 Radar Set is a HI-PAR consisting of an antenna group, transmitter, receiver/processor and target processing circuitry. The radar performs interlaced scan and track functions (including target acquisition) which provide accurate data for aircraft ground approach guidance, during both clear and adverse visibility conditions. The scan function involves scan of the airspace over a selected runway. The track function involves accurate determination of target elevation, azimuth and range position. The scanned airspace consists of a sector from -1° to $+7^{\circ}$ in elevation and from -10° to $+10^{\circ}$ in azimuth. The maximum range is 20 NM; however, operation at ranges of 15 or 8 NM is also available.

(1) Antenna Group. The entire airspace is scanned electronically twice each second for the 20 NM range and 2.4 times each second for the shorter ranges. This is accomplished by using a digitally controlled, phased-array which allows coverage of the entire radar volume with no movement of the antenna. The pencil beam of the antenna is directed by the electronic control of 443 ferrite phase shifters. Scanning is done by changing the antenna beam position in 439 discrete steps, covering a 2 dimensional raster, with one dimension representing azimuth and the second, elevation. The antenna beam position control unit is the functional component located in the shelter that accepts target data computer beam commands and calculates phase-shifter angle commands. Each of the 439 beam positions is held constant for three PRF perods for the scan modes and 4 PRF periods for the acquisition or track mode. Three sequential target returns are thereby provided for each beam position during the scan function. The three returns are utilized to provide noncoherent MTI operation permitting aircraft radar echoes to be distinguished from fixed clutter, rain or chaff. For areas where clutter or interference is not a problem, particularly at the far end of the radar range, the sequence of three target returns for each beam position permits an integration (summing) function to be accomplished to strengthen the weak target echoes, particularly in the presence of thermal noise. The actual selection between integration and MTI operation for the scan video is accomplished at the Radar Set Control.

(2) Transmitter. The transmitter contains a VHF to X band multiplier/amplifier and a PIN diode modulator. The output is used to drive a two stage power amplifier consisting of a low power TWT and a high power CFA. The CFA may be switched off when only low power is required or during periods of clear or light weather, thus increasing the life of the tube. Although both stages of the transmitter power amplifiers are air cooled, waveguide presurization is required for CFA operation.

(3) Receiver/Processor:

(a) The receiver portion of the receiver/processor is divided into two functional sections, the scan receiver used during the scan function and the range and angle tracking receivers for the track function of the radar. The receiver front end is located in an enclosure behind the antenna main reflector to minimize return signal losses and hence to assure low noise, good signal sensitivity and target tracking stability.

1. Scan Receiver. The scan receiver is a dual channel frequency diversity receiver. One channel handles the first half of the received pulse and the second channel processes the second half-pulse which is 37 MHz higher in frequency. Each channel then divides into a coherent MTI receiver, a noncoherent MTI receiver and a normal receiver.

2. Tracking Receiver. The tracking receivers perform the processing and detection of the sum and difference channels to provide range, azimuth and elevation tracking errors on the designated targets. The error detector outputs are fed to the TDC to update the beam position data during the next track interval.

(b) Processor. The processor consists of four principal parts: PRF generator, range gate generator, target detector/track error quantitizer and computer interface circuits. In addition, it contains a clutter detector/logic generator circuit.

(4) DMTI. The DMTI interference blanker is used to cancel radar clutter returns without appreciable loss of moving target information. It also provides integration of normal video radar returns and is capable of blanking second-time-around target returns. Since the PAR utilizes frequency diversity, the DMTI has two channels which process each 0.5 usec subpulse separately prior to summing.

(5) Indicators. Three identical indicators are used in the AN/GPN-22, two in the operations area and one as an in-shelter maintenance monitor. The PAR display utilizes a 16" CRT with a beta scan format presentation providing a three-dimensional view of the entire PAR coverage volume. Target azimuth, elevation and range are displayed on the CRT via two simultaneous presentations. The display provides instantaneous and independent controller selection of 8, 15, or 20 NM range scales, each with a range mark interval of 1.0 NM with every fifth one intensified. The elevation glide path cursors, azimuth courseline, ground references and a decision height marker are also displayed.

(6) TDC. The TDC is a general purpose microprocessor which stores and executes the radar operational program. The TDC on-line program includes:

(a) Overall executive control and initialization of program components.

(b) Track computation and next-look prediction for up to six sequentially tracked targets.

(c) Operator Selectable Glide Path and Target Position Computations to service the displays.

(d) The search program, acquisition program, and subroutines to control search, acquisition and track/scan time-sharing for the entire radar set.

(e) Antenna beam-pointing angle by commands to the beam-steering control processor.

(f) Detection of computer program and peripheral interface faults.

b. Facility Equipment: AN/GPN-22, SN 18

c. Environmental Factors:

(1) Siting. The PAR is located between the two parallel runways as shown in Attachment A2-1 and provides services to all four runways. The panaromic photographs in Attachments A4-1/2 show the areas over which the approaches are flown. The mountains 30-35 NM to the south shoutwest limit the perfromance of the system to runway 03 (see para 4, this section). Analysis of the screening angles on the skyline graphs indicate there is no screening angle large enough within the scan areas to screen the glideslope intercept altitudes.

(2) Weather. The weather conditions discussed in Appendix III, para 1c(2) applies to the PAR as well as the ASR and ATCRBS. Weather was not a factor during the evaluation.

(3) EMI. No EMI to the AN/GPN-22 was observed during the evaluation.

2. Equipment Status:

a. Facility Equipment Status. Equipment checks were performed in accordance with existing technical orders and current evaluation procedures. Results of these checks are presented in Attachments A18-1/2. Pre and post flight equipment checks were conducted ensuring the radar was stable at or above minimum operating standards during the flight phase (see Attachment A20-1). Equipment operation was satisfactory except for noncoherent MTI, which failed before the PAR was commissioned to runways 21R and 21L.

(1) A scan receiver module was replaced when low MDS figures for the receiver spectrum were obtained. System measurements with the built in monitoring equipment showed the original scan module to be faulty.

(2) Computer Control and Associated Software. Several faulty program loads were encountered with the tape reader assembly. Investigation of this matter further revealed a misaligned read station such that illumination of all the sensors by the lamp was not being accomplished. This condition was further worsened by the fact that the installed rod lamp had a bent filament. A field alignment of the lamp holder assembly and replacement of the rod lamp achieved satisfactory operating results. A replacement tape reader assembly was placed on order. Although the presently installed unit was now functioning properly, the read station assembly had to be re-calibrated for proper trouble-free operation. It was also considered that the field alignment was only a temporary remedy at best and that the new tape reader should be installed upon receipt.

b. Test Equipment Status. Considerable trouble was encountered with the Hewlett Packard 620B signal generator. Several different generators were used during this evaluation and frequency stability was unacceptable. A useable 620B signal generator was finally obtained from an on-base organization and was used throughout the evaluation.

3. Evaluation Overview. The best way to measure radar performance is by tracking a known target and comparing the results with theoretial predictions and previous data collected from similar radars. Before tracking a known target, the equipment must be ruled out as a cause of performance degradation. Because of this, the evaluation consisted of two phases: a ground phase and flight phase. Specific objectives and methods for each phase are explained in the following paragraphs.

a. Ground Phase:

(1) To ensure that equipment performance had no adverse effect on the evaluation results, extensive equipment checks were performed to verify that system parameters met technical order specifications.

(2) To verify the PAR angle an airfield survey was performed to determine the distances and angles required for site parameter panel settings.

(3) To document the environmental effects on PAR coverage, a horizontal screening survey was performed. Also, data on terrain features, EMI and weather conditions were collected and analyzed.

(4) To ensure proper equipment performance during the flight phase, pre and post flight equipment checks were performed.

b. Flight Phase. The second phase consisted of sorties flown with a C-140 flight inspection and with F-5 fighter aircraft to determine the capabilities and limitations of the PAR. The flight phase objectives are stated in the following paragraphs.

(1) To verify that the new cursor angles were correct, a theodolite was used to measure the actual glide path flown.

(2) To document the effects of the PAR special features, the aircraft were flown on repeated approaches to all four runways with different features selected.

(3) To document the limitation due to multipath propagation, multiple approaches were flown to the different runways.

c. Equipment Configuration. Unless otherwise noted, all flight data were collected with the following PAR configuration: FTC-OFF, coherent MTI, STAR setting 1, baseline clipping 0, and acquisition gain Low.

4. Analysis of Evaluation:

a. Radar Coverage Limitations. The acqusition and tracking of aircraft using Normal video was impossible due to the high clutter returns (see Attachment A13-1). These clutter returns are a combination of primary returns off the building in Las Vegas, NV and second-time-around returns from the mountains, 30-35 NM away. The severity of the second-time-around clutter is shown in the photographs taken of MTI video. This clutter is affected by indicator range and vertical beam scan. Changing the indicator range from 20 NM to either 8/15 NM moves the clutter from between 3-6 NM to between 6-10 NM (see Attachment A13-2). These photographs are for a vertical beam of -1.0° to $+7.0^{\circ}$.

Even in the MTI Mode, it was not possible to track aircraft. A Raytheon recommendation of modifying the vertical beam scan to $+1.5^{o}$ to 7.0^{o}, with a STAR setting of 1 and baseline clipping of 0 was implemented resulting in decreased second-time-around clutter (see Attachment A13-2). Aircraft detection and tracking was possible using this change. The AN/GPN-22 has the capability to process and minimize second-time-around clutter within the DMTI circuitry. Even when using the maximum threshold of 7, the amplitude of the second-time-around targets, when viewing the 03 approach area, were of such magnitude, that the smaller real time return was insignificant at the comparitor circuits of the analog to digital converter. This results in an almost constant STAR inhibit condition whereby the target information in the range bin is not processed for display. Only when the real time target video is greater than the STAR video will the range bin's information be processed for display. Since MTI is required for the entire indicator presentation, the DMTI cannot eleminate this second-time-around clutter. The approaches to runways 21L and 21R are over gently upsloping terrain which rises to the mountain 13 NM away. This area is free of objects which cause strong clutter returns. With the elevation beam scan of -1.0^{o} to $+7.0^{o}$ there were no noticable second-time-around clutter problems. The analysis of the screening angles on the skyline graphs indicate there is no screening angle large enough within the scan area to screen the glide slope intercept altitudes (see Attachments A4-1/2).

b. Glide Path. During the flight checks on 2 February, the PAR glide path averaged 3.04^{o} and 3.10^{o} and the safety cursor averaged 2.52^{o} and 2.52^{o} for runways 03R and 03L respectively (see Appendix V, Table 1). The approaches to runway 03R were well within commissioning criteria of $3.00^{o} \pm 0.10^{o}$. The approaches to runway 03L just met commissioning criteria; however, the reason for this difference cannot be explained at this time. During preliminary equipment checks on 1 March using the Performance Assessment Tape, excessive tracking error was noted during the elevation angle error test 0.8^{o} for the reference reflector angle of 0.8^{o}. The angle error test indicated acceptable tracking when the reference reflector angle was changed to 0.9^{o}. With a reference reflector angle of 0.8^{o}, flight checks to runway 21R and 21L on 2 March resulted in out-of-tolerance glide path angles of 3.14^{o} and 3.22^{o} respectively. However, when the reference reflector angle was changed to 0.9^{o}, the glide paths flown were 3.11^{o} and 3.09^{o} for runways 21R and 21L respectively. The survey data was verified to be correct and that the reference reflector was indeed at a 0.8^{o} angle above antenna focal point. Resiting the reference reflector pole 387 feet closer to the PAR and lowering the reflector by six feet did not improve the results of the Angle Error Test. However, when additional portions of the old AN/MPN-13 turntable were removed, the Elevation Angle Error Test improved to within tolerance. Subsequent flight checks resulted in average glide path angles of 2.92^{o} and 2.91^{o} and safety cursor angles of 2.51^{o} and 2.56^{o} for runways 21R and 21L respectively. Approaches were flown to each runway while using the backup operational tape to control the PAR and the results are listed in Table 5-1. The angles flown were within commissioning tolerance and better than the primary Operational Program tape. While the primary and backup Operational Program computer tapes are allegedly the same, the differences between the angles flown cannot be explained at this time. It is recommended that the backup tape b used full time and that the primary tape be used as the backup tape.

TABLE 5-1

COMMISSIONING FLIGHT DATA

DATE	RWY	GLIDE SLOPE	DETECTION RANGE(NM)	REMARKS
2 Feb	03R	3.04	18.5	
2 Feb	03R	3.04	18.5	
2 Feb	03L	3.10	14.0	
2 Feb	03L	3.10	12.0	
2 Feb	03L	2.52	12.0	Note 1
2 Feb	03R	2.52	12.0	Note 1
2 Feb	03L	3.08		
2 Mar	21R	3.14	10.0	Note 2
2 Mar	21L	3.22	18.0	Notes 2,3
2 Mar	21R	3.11	10.0	Note 3
2 Mar	21L	3.09	18.0	Note 3
4 Mar	21R	2.93	10.0	Note 2
4 Mar	21R	2.91	10.0	Note 2
4 Mar	21L	2.90	10.0	Note 2
4 Mar	21L	2.91	10.0	Note 2
4 Mar	21R	2.51	10.0	Note 2
4 Mar	21L	2.57	10.0	Note 2
4 Mar	21L	2.57	10.0	Note 2
4 Mar	21L	2.56	10.0	Note 2
5 Mar	03R	3.01	10.0	Note 2
5 Mar	03L	3.07	10.0	Note 2
5 Mar	21R	2.99	10.0	Notes 1,2
5 Mar	21L	2.98	10.0	Notes 1,2
5 Mar	03R	2.54	10.0	Notes 1,2
5 Mar	03R	2.54	10.0	Notes 1,2
5 Mar	21L	2.45	10.0	Notes 1,2
5 Mar	21L	2.43	10.0	Notes 1,2

Note 1 - Safety Cursor

Note 2 - Track cut short to conserve fuel.

Note 3 - Reference reflector angle is 0.9°

c. Feature Comparison:

(1) MTI:

(a) The MTI receiver is a phase locked system, basing a phase detection process on a reference of the transmitted pulse phase, cancelling the present and prior radar intervals and dictating the remaining residue as a moving target. The noncoherent receiver functions exactly as the standard MTI receiver except the phase reference is not taken from the transmitter pulse but from a target within the received period. This makes the receiver virtually immune to slow moving clutter such as rain. Since the rain clutter's phase is used as a reference, only targets that are moving faster than the rain are seen by the operator. Due to the detection characteristics of the noncoherent receiver and its reduced sensitivity, the use of greater transmitted power is necessary to provide reliable operation and detection of targets during periods of rain.

(b) As discussed in para 4a of this section, it was not possible to track aircraft using Normal video. The commissioning flight checks of the coherent and noncoherent MTI modes for approaches to runways 03R and 03L were performed in February for the primary Operational Program tape. Detection and tracking of F-5 size aircraft was possible from 14 NM to touchdown and C-140 and F-4 size aircraft were tracked from 18 NM to touchdown. In March, both the primary and backup Operational Program tapes were commissioned for approaches to runways 21L and 21R using only coherent MTI due to equipment failure in the noncoherent MTI system. A C-140 and F-4 aircraft were detected and tracked from 19 NM to touchdown for approaches to runways 21L and 21R, aircraft were detected at 16 to 18 NM on approaches to runways 03R and 03L. Additionally, the backup Operational Program tape was commissioned for coherent MTI operation only to runways 03R and 03L. This unit is restricted to using coherent MTI for approaches to all runways and is also restricted from using noncoherent MTI until that feature is repaired and flight checked.

(2) PAR Performance 1/2/3. These pushbuttons are used to select different bandwidth parameters for optimum target tracking. Position 1 provides maximum frequency diversity and minimum receiver sensitivity and is best suited for large targets. Position 3 provides maximum signal-to-noise ratio and is used for weak, distant targets. The bandwidth change between position 1 and 2 is accomplished automatically under TDC control but may be manually overridden at any time. Position 3 is not under automatic control but can be selected manually if desired. During the flight phase, the PAR Performance automatically switched between position 1 and 2 once target tracking occurred. On selected tracks, PAR Performance 3 was manually selected when tracking F-5 aircraft. Using a PAR Performance setting of 1, improved target definition was obtained when tracking F-4 or larger size aircraft within 4 NM. Recommend PAR Performance 1 be used for tracking large aircraft when they are within 4 NM.

(3) Acquisition Gain High/Low:

(a) In high power it is difficult to distinguish the target boundaries at short ranges, the Acquisition Gain Hi/Low control should be switched to the Low position. The Low position reduces the receiver front end gain by 18 dB for the first four miles. This reduces target bloom and makes locating the target center easier.

(b) During the flight phase, Acquisition Gain Low was used on selected tracks. The C-140 aircraft was sucessfully tracked on all approaches. A series of tracks were flown using High and Low while using F-5 aircraft. Tracking in either mode was successful. Acquisition Gain Low is recommended when using high power and conducting approaches of C-141 or larger aircraft.

(4) STAR:

(a) The alternation of transmitted frequencies (every group of three PRT's) is used by the DMTI sub-circuitry to identify second time around radar returns. Once a range bin has been identified as having a STAR target within it's limits, the entire bin output is inhibited. The STAR threshold thumbwheels establish the minimum magnitude for a return to be identified as a second-time-around target and cancels any returns within the range bins that are below this threshold level.

(b) During the ground phase, the eight different STAR settings were analyzed to determine their effect on eliminating second-time-around clutter. Though there was some reduction in clutter returns as the STAR level was increased from 0 through 7, the remaining level of second-time-around clutter limited aircraft detection and tracking. During the flight phase, STAR settings of 0, 1, and 2 were evaluated on selected tracks with no appreciable difference between any of the settings. At the recommendation of Raytheon, the unit was commissioned with a STAR setting of 1 and it is recommended that this setting be used continuously.

(5) Baseline:

(a) These thumbwheels select the digital level of video which will be utilized as the baseline for the reconstructed analog video. This effectively reduces the amount of low level noise present on the indicator. Since the circuitry does not distinguish between weak targets and noise or "grass", this function is not normally used.

(b) During the ground phase, different baseline settings were analyzed to determine the effects on reducing clutter returns. Increasing the level decreased the receiver sensitivity and corresponding clutter returns. Selected baseline settings were flown during the flight phases; however, no improvement in tracking was observed for any of the settings. Recommend that the commissioned setting of 0 be used for day-to-day operation.

(6) High/Low Power:

(a) The low power mode is used for normal day-to-day clear weather operation. During periods of heavy rain squalls or severe interference, when the noncoherent receiver is utilized, it may be necessary to use the high power mode. This mode develops a peak RF power output of 250 kW minimum.

(b) In low power for either coherent or noncoherent MTI, a C-140 size aircraft was tracked and acquired from 18 NM to touchdown and an F-5 size aircraft was tracked from 14 NM to touchdown. Use of high power made acquisition of targets in areas of second-time around clutter more difficult as the track receiver frequently locked on noise. Multipath propagation was noted

within decision height on approaches to all runways. In high power, tracking was unacceptable as the track receiver consistantly broke lock on the target. The system was restricted to operate in low power only until Raytheon provides a suitable solution to this problem.

(7) FTC. The control improves target visibility when the target is located in a large block of clutter. The clutter is effectively broken up into leading edges of video thus reducing its masking effects. During the flight phase, selected tracks were flown with the FTC on and off. There was some improvement in tracking targets through clutter using FTC. The FTC feature should be used at the individual controller's discretion.

APPENDIX VI

POWER SYSTEM

1. System Descriptior. The primary input power to the AN/GPN-24 is supplied by a commercial source. If a malfunction occurs to the source, diesel powered generating systems are automatically switched on and used until commercial power is restored. These generating systems are identified in Attachments A19-1/2.

2. Equipment Status. The backup generator for the AN/GSN-12 shelter and AN/GPN-20 ASR was tested with satisfactory results. The backup generator to the AN/GPN-22 did not have an auto-start capability.

3. Evaluation Overview. The best way to measure the backup power performance is by simulating a commercial power failure and analyzing the backup system's ability to come on line and assume the load. The backup system must be checked for its ability to operate under normal load fluctuations.

4. Analysis of Evaluation. The primary and backup power are considered adequate to support the AN/GPN-20 and the AN/GSN-12. However, the backup generator to the AN/GPN-22 was not adequate nor reliable. This is because when the air conditioning unit to PAR came on, the input voltage to the AN/GPN-22 fell below the minimum line voltage. The internal fault circuitry, sensing the low voltage, shut down the PAR unit. Recommend that the base civil engineer be contacted to provide adequate backup power.

Attachment 1

TITLE

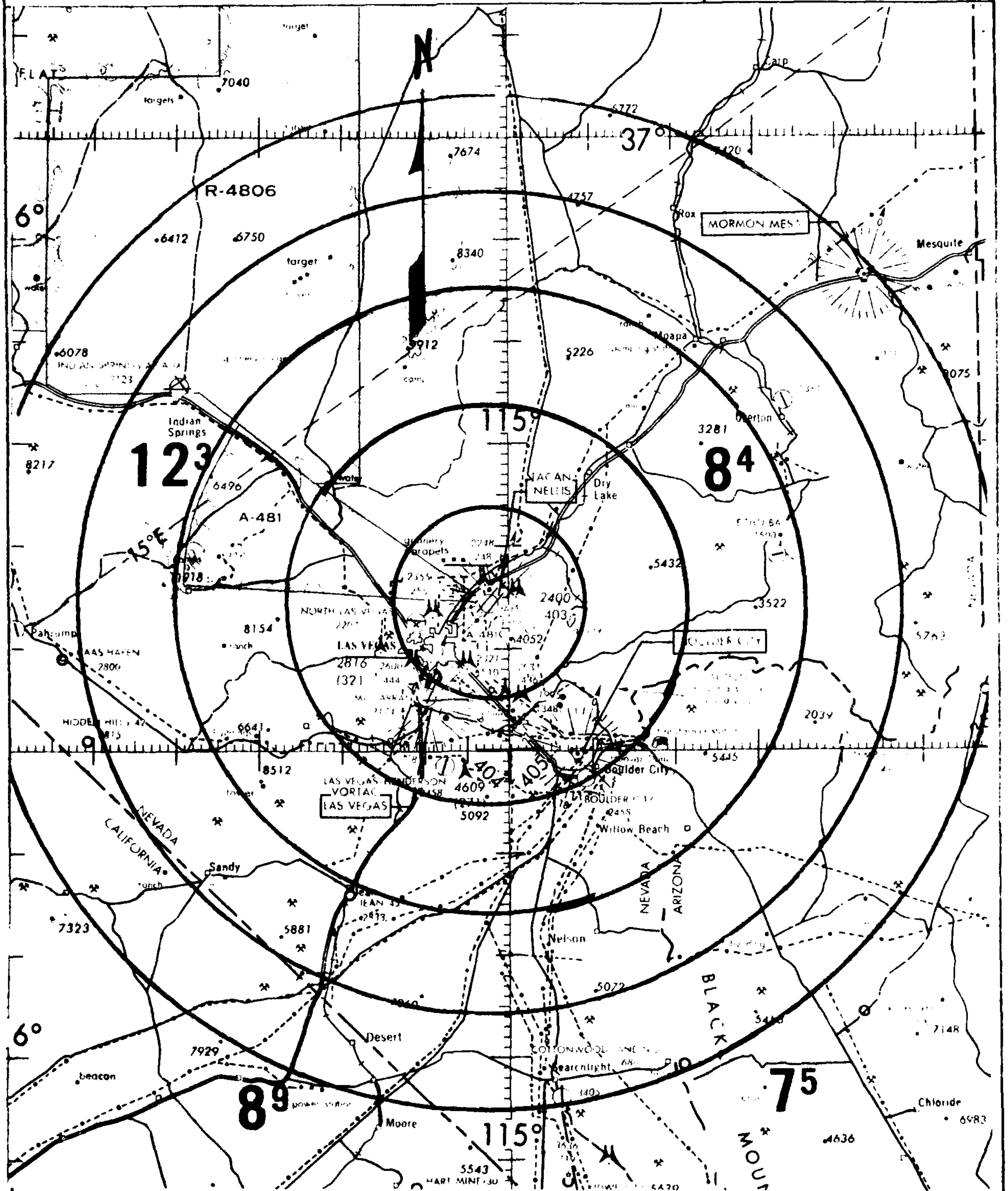
AREA LOCATION MAP

LOCATION

Nellis AFB

DATE

January 1980

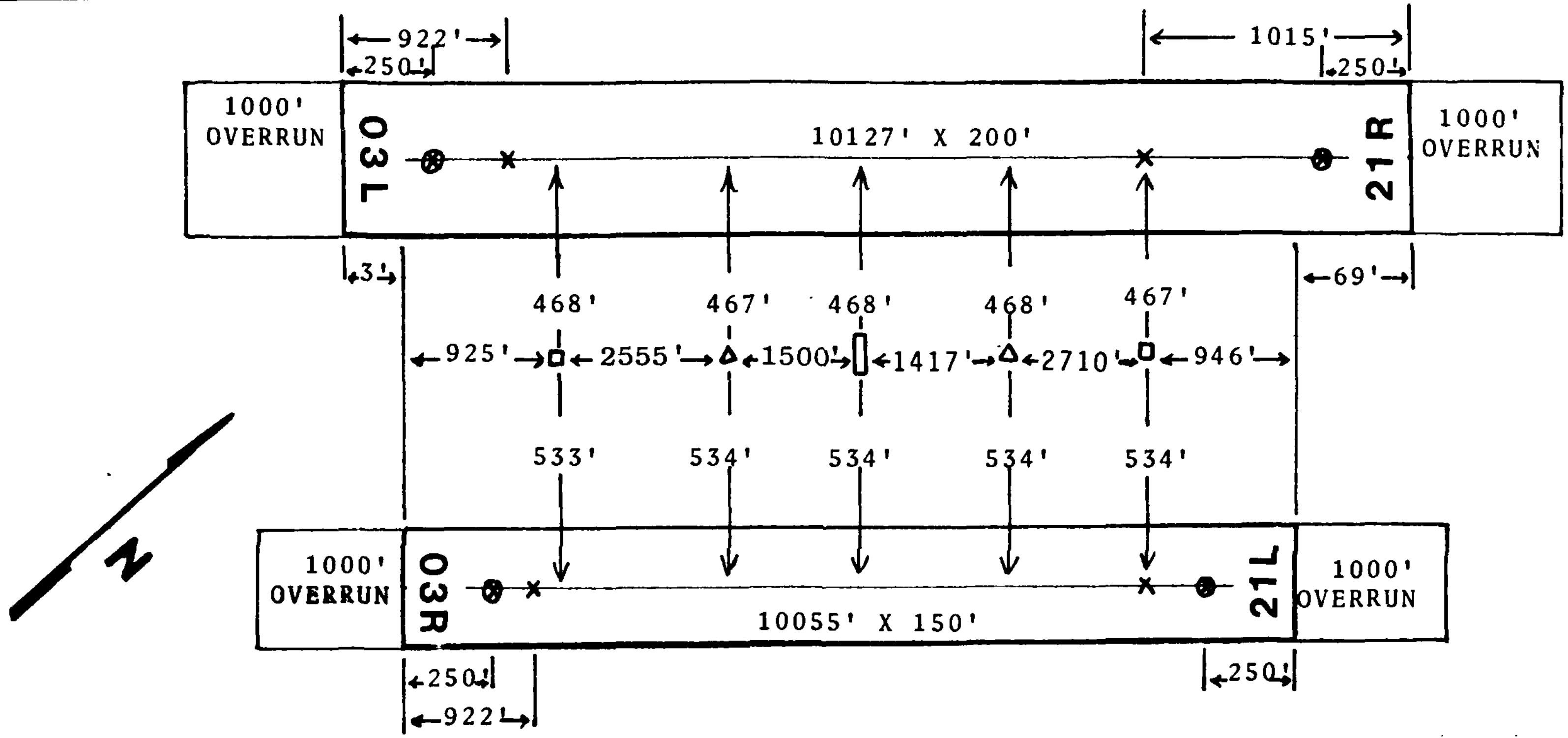


REMARKS

SCALE 1,000,000:1
10NM range marks

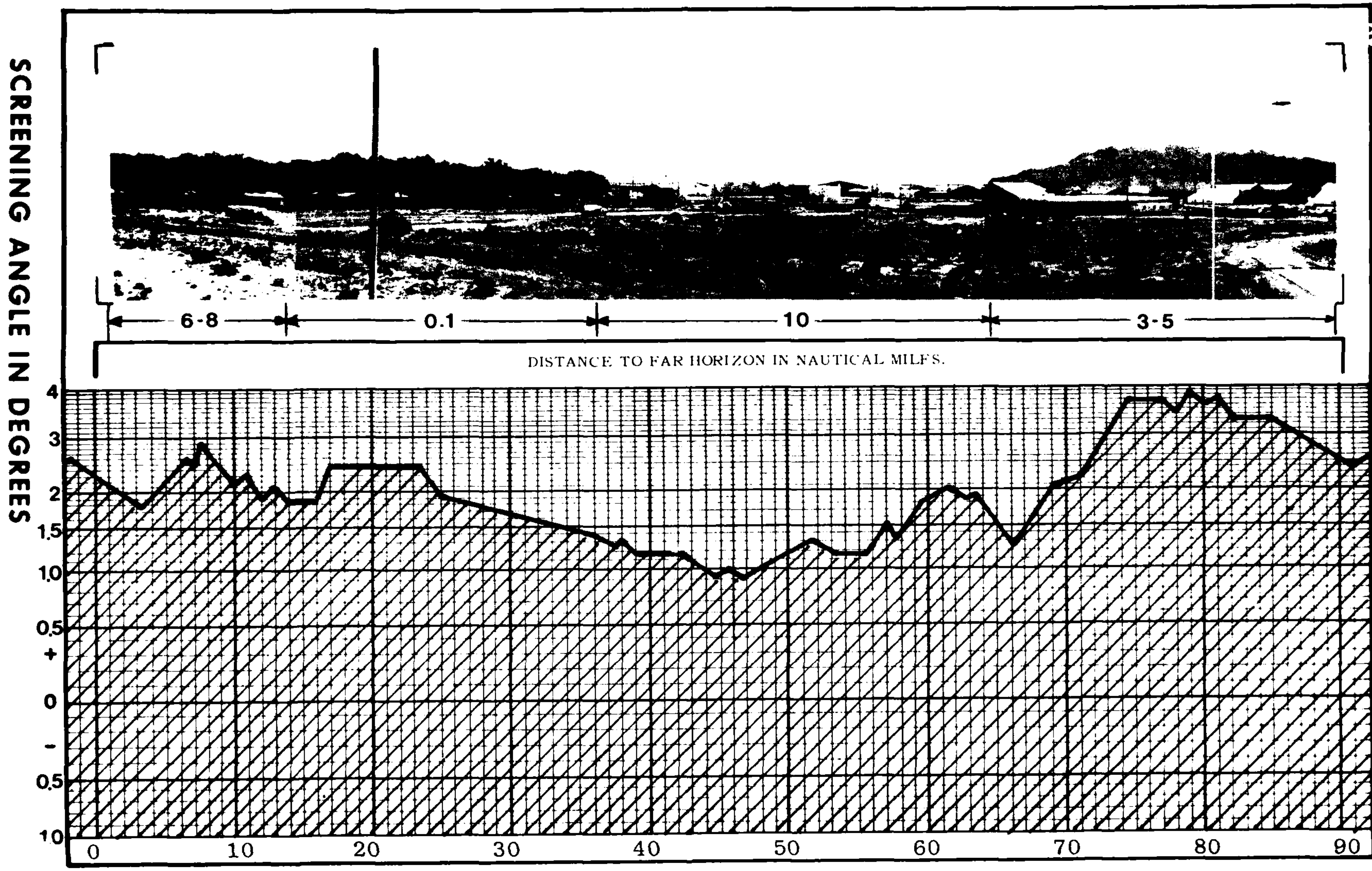
RUNWAY DATA

LOCATION	RUNWAY	DATE / SCALE
Nellis AFB	03-21L, R	4 Mar 1980 / Not to Scale



LEGEND		ELEVATION			ELEVATION
x TD POINTS	03L	1835.7 FT MSL		END OF RUNWAYS	03L 1833.7 FT MSL
	03R	1827.6 FT MSL			03R 1826.0 FT MSL
	21L	1861.5 FT MSL			21L 1864.9 FT MSL
	21R	1866.0 FT MSL			21R 1868.9 FT MSL
◘ MTI REFLECTORS	NORTH	1862.3 FT MSL	STAKE	⊗ LOWER SAFE LIMIT	
	SOUTH	1830.6 FT MSL	RELOCATED STAKE	LINE GPI (GPT)	03L 1834.2 FT MSL
△ REFERENCE REFLECTORS		1871.2 FT MSL	SOUTH		03R 1825.5 FT MSL
		1869.9 FT MSL	NORTH		21L 1864.0 FT MSL
▯ AN/GPN-22 PAR		1850.5 FT MSL			21R 1868.1 FT MSL

SKYLINE GRAPH



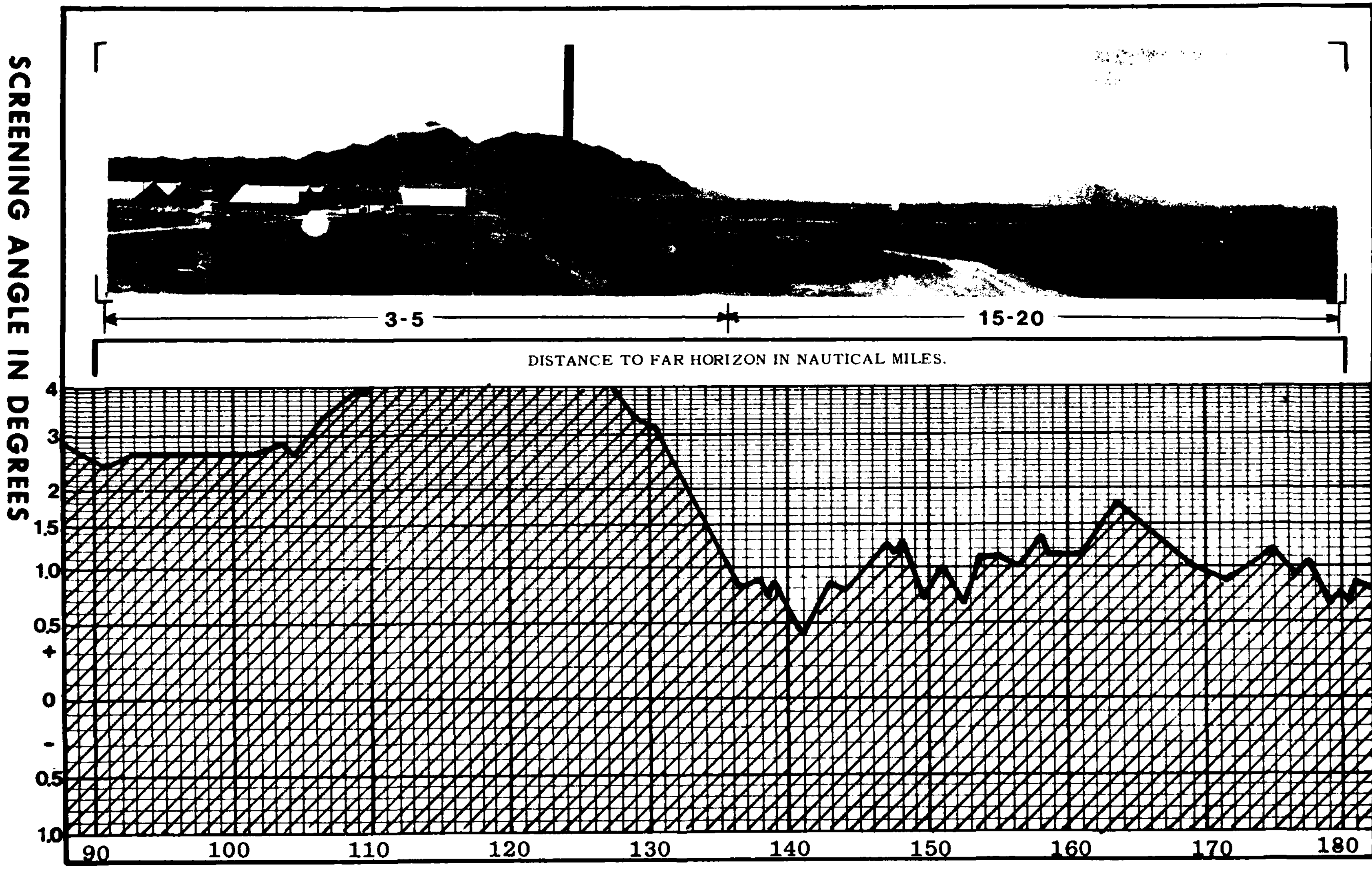
ORIENTED TO: MAGNETIC NORTH

AFCS ... 913 MAGNETIC VARIATION: 15° E

STATION NELLIS AFB

EQUIPMENT AN/GPN-20

SKYLINE GRAPH



ORIENTED TO: MAGNETIC NORTH

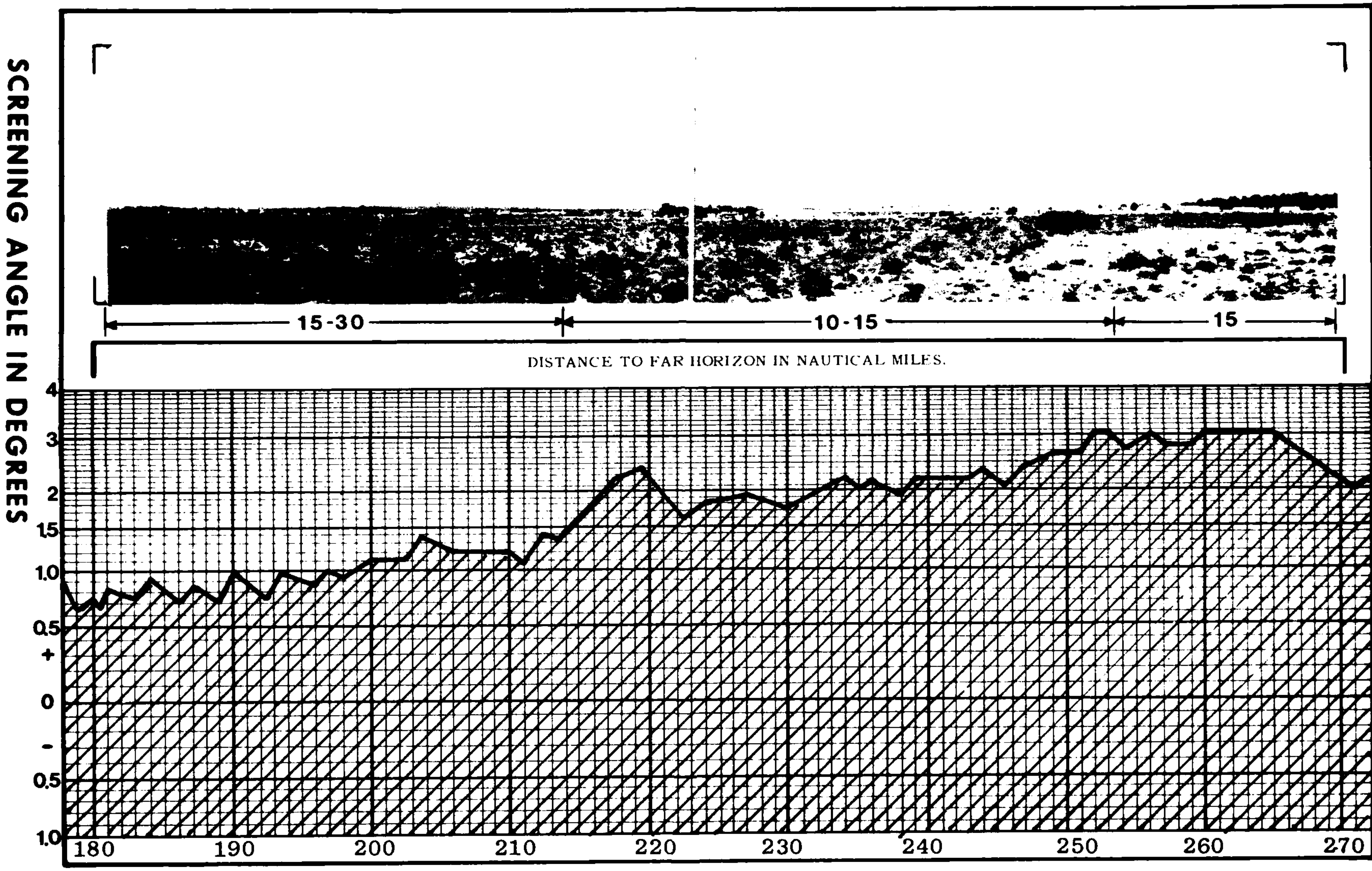
MAGNETIC VARIATION: 15° E

STATION NELLIS AFB

EQUIPMENT AN/GPN-20

AFCS FORM MAY 73 913

SKYLINE GRAPH



ORIENTED TO: MAGNETIC NORTH

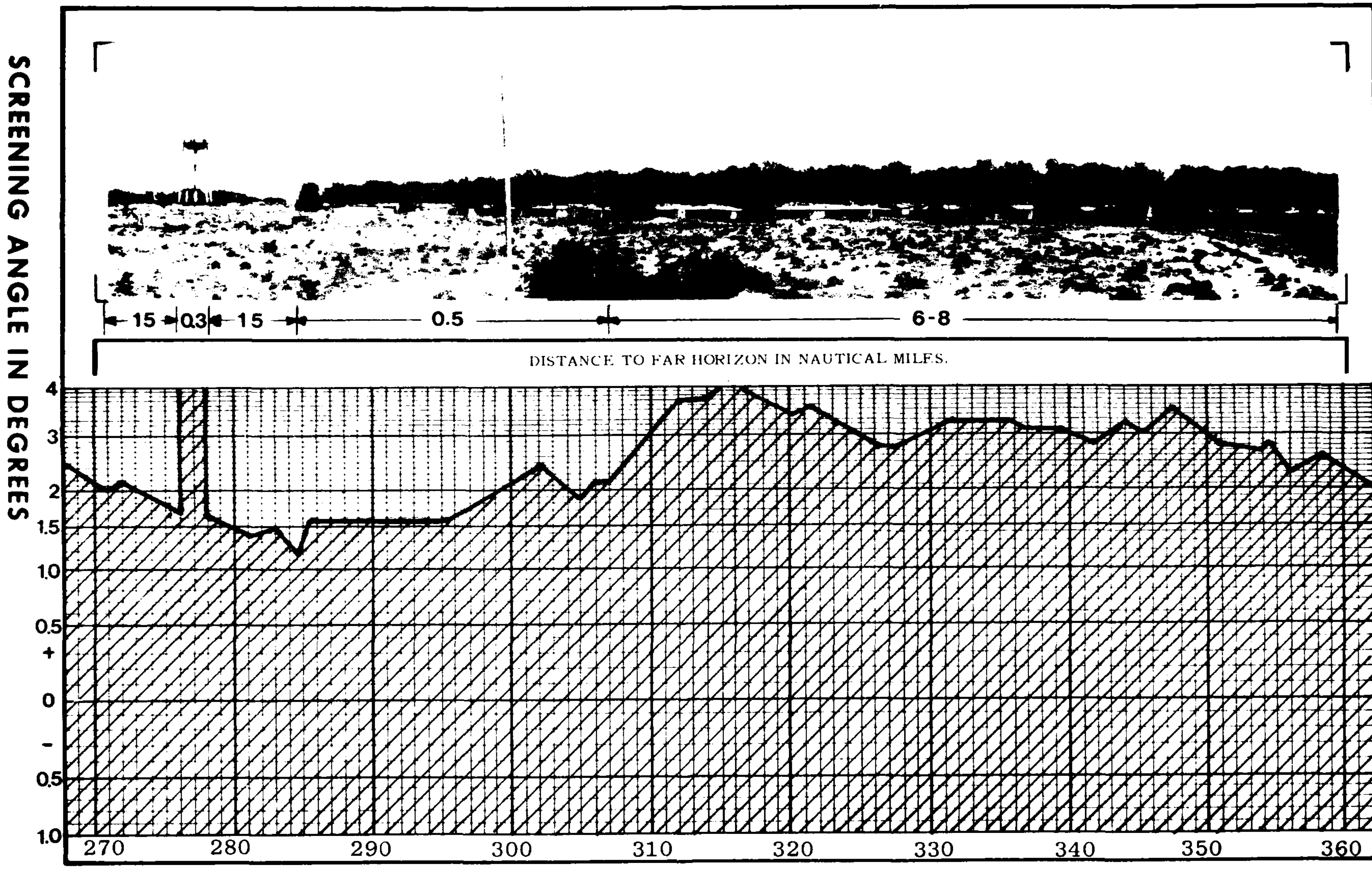
MAGNETIC VARIATION: 15° E

STATION NELLIS AFB

EQUIPMENT AN/GPN-20

AFCS FORM 913

SKYLINE GRAPH



ORIENTED TO: MAGNETIC NORTH

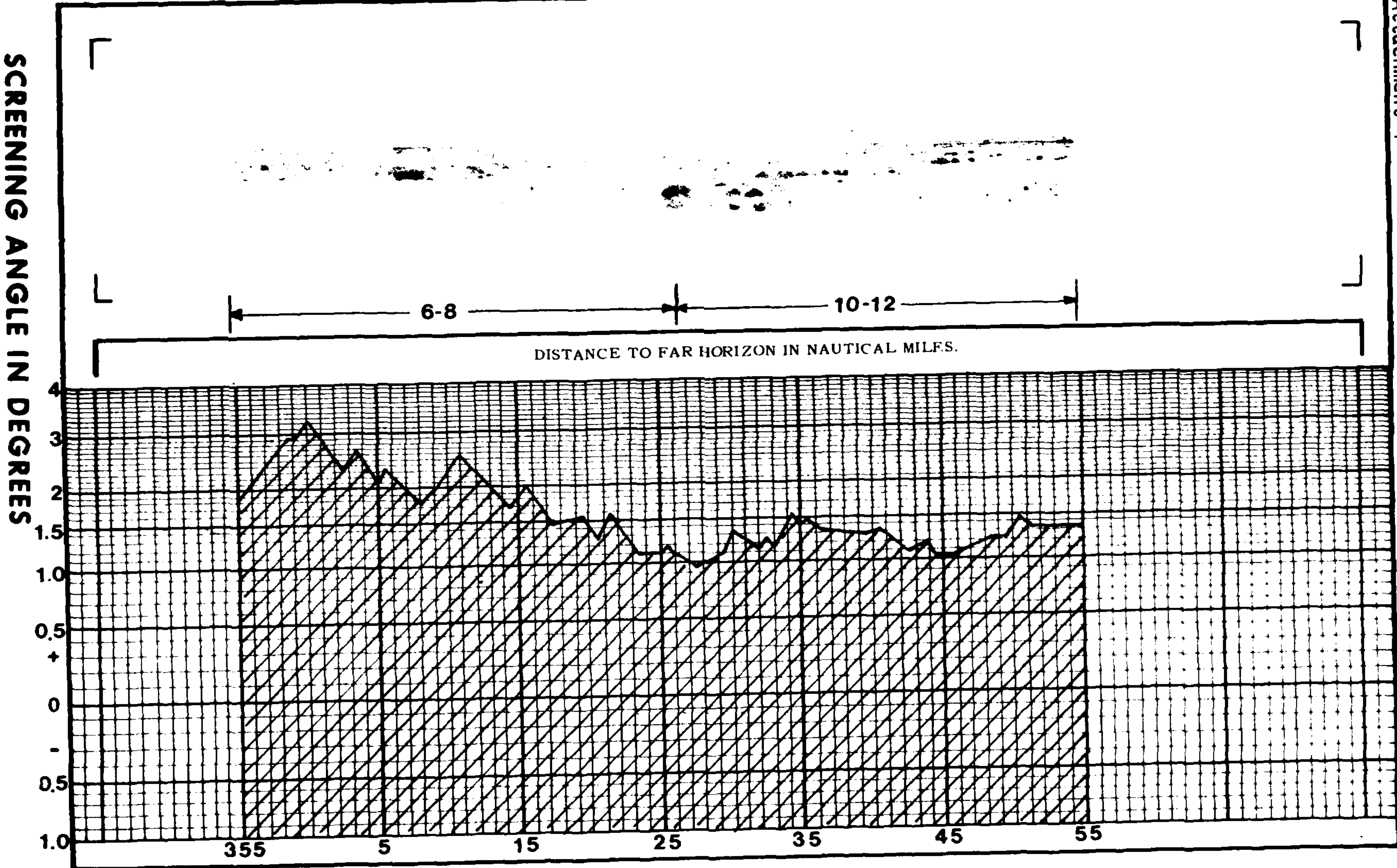
MAGNETIC VARIATION: 15° E

STATION NELLIS AFB

EQUIPMENT AN/GPN-20

AFCS ... 913

SKYLINE GRAPH RUNWAY 21

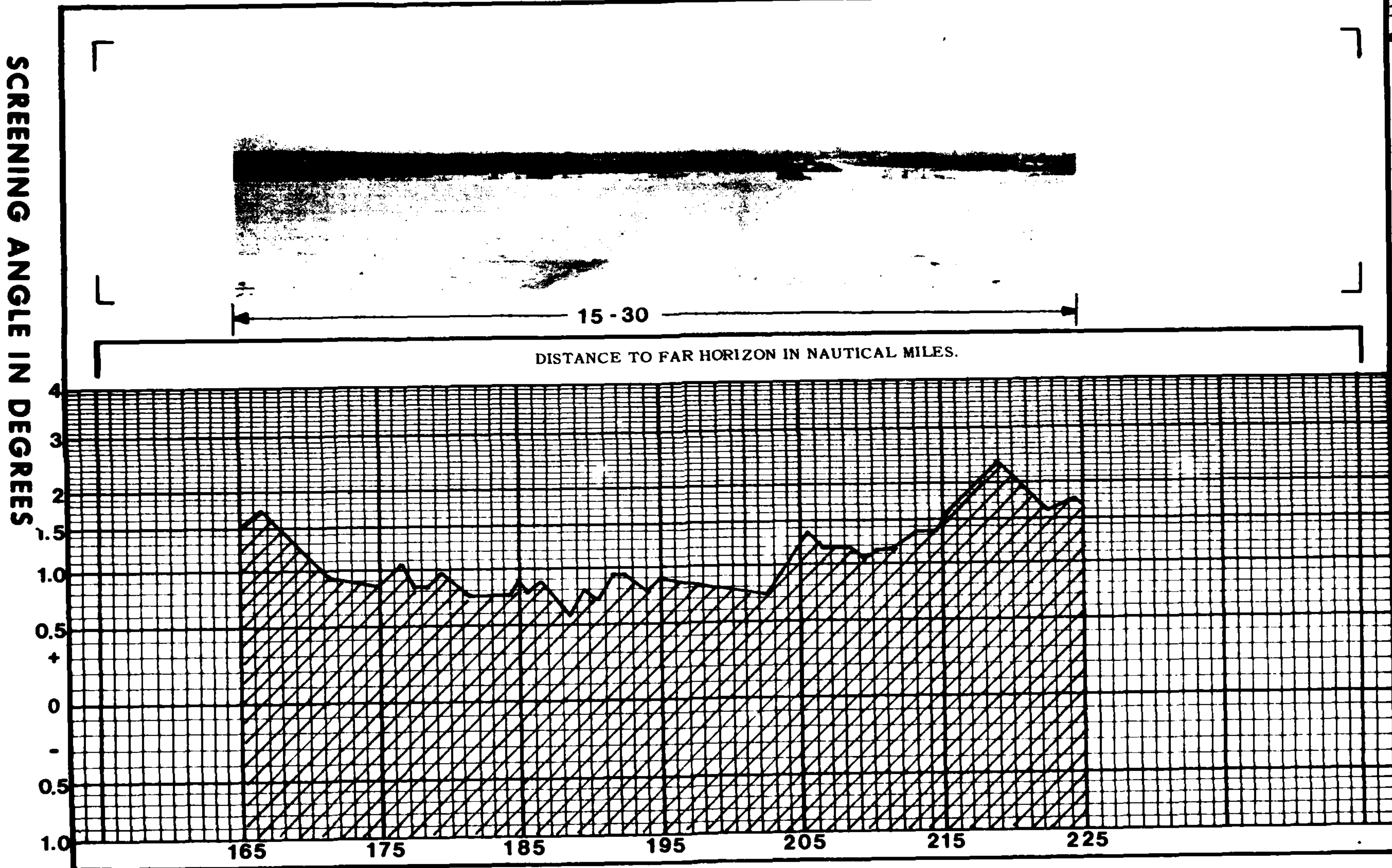


ORIENTED TO: MAGNETIC NORTH
MAGNETIC VARIATION: 15° E

STATION NELLIS AFB
EQUIPMENT AN/GPN-22
PAR

AFCS FORM 913

SKYLINE GRAPH RUNWAY 03



ORIENTED TO: MAGNETIC NORTH

MAGNETIC VARIATION: 15° E

STATION NELLIS AFB

EQUIPMENT AN/GPN-22

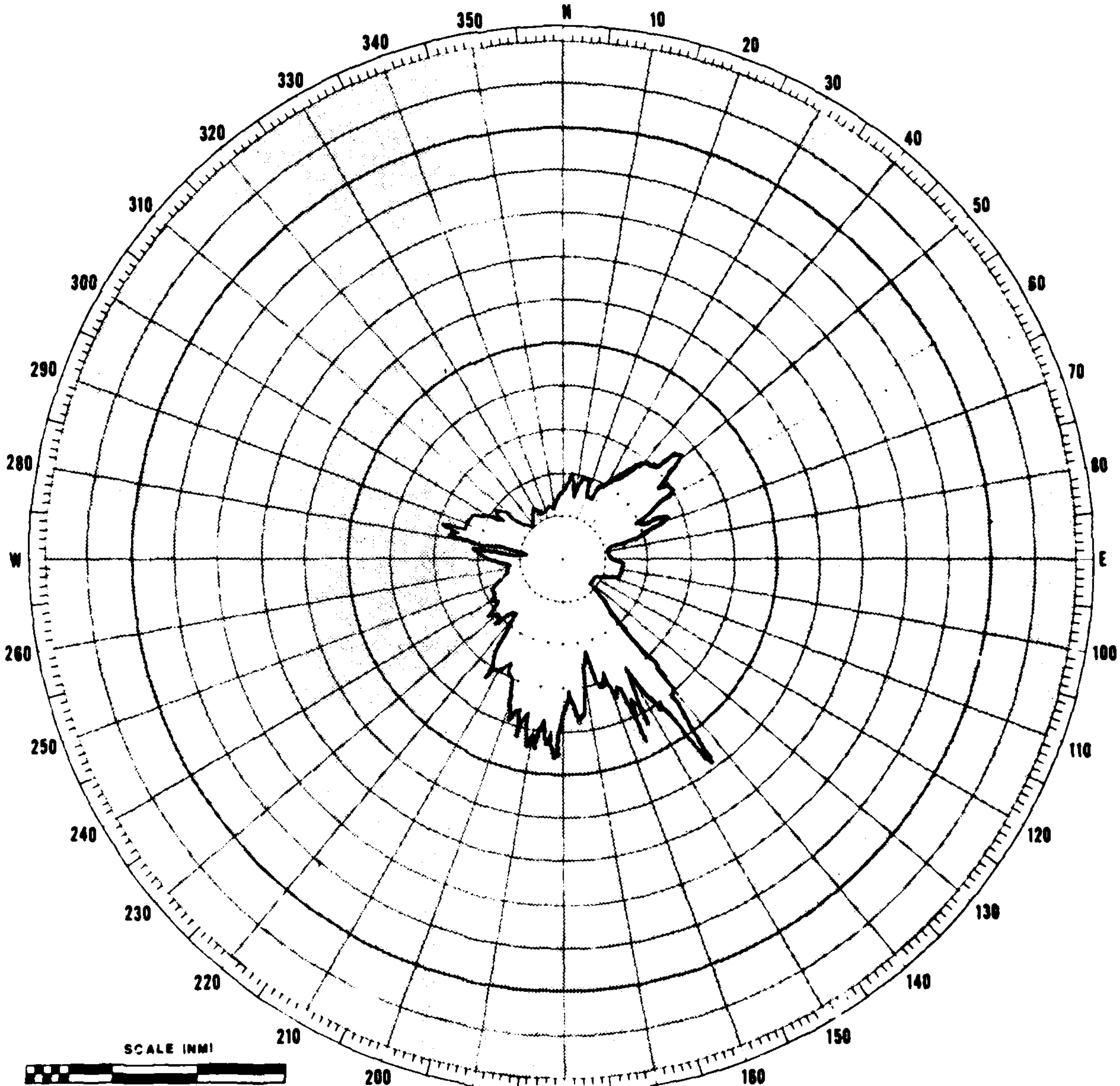
PAR

AFCS FORM MAY 73 913

TITLE

LINE OF SIGHT COVERAGE

LOCATION	DATE
Nellis AFB	January 1980



Indicates area of no coverage due to screening.

REMARKS

5 NM range marks
4,000 feet MSL

TITLE

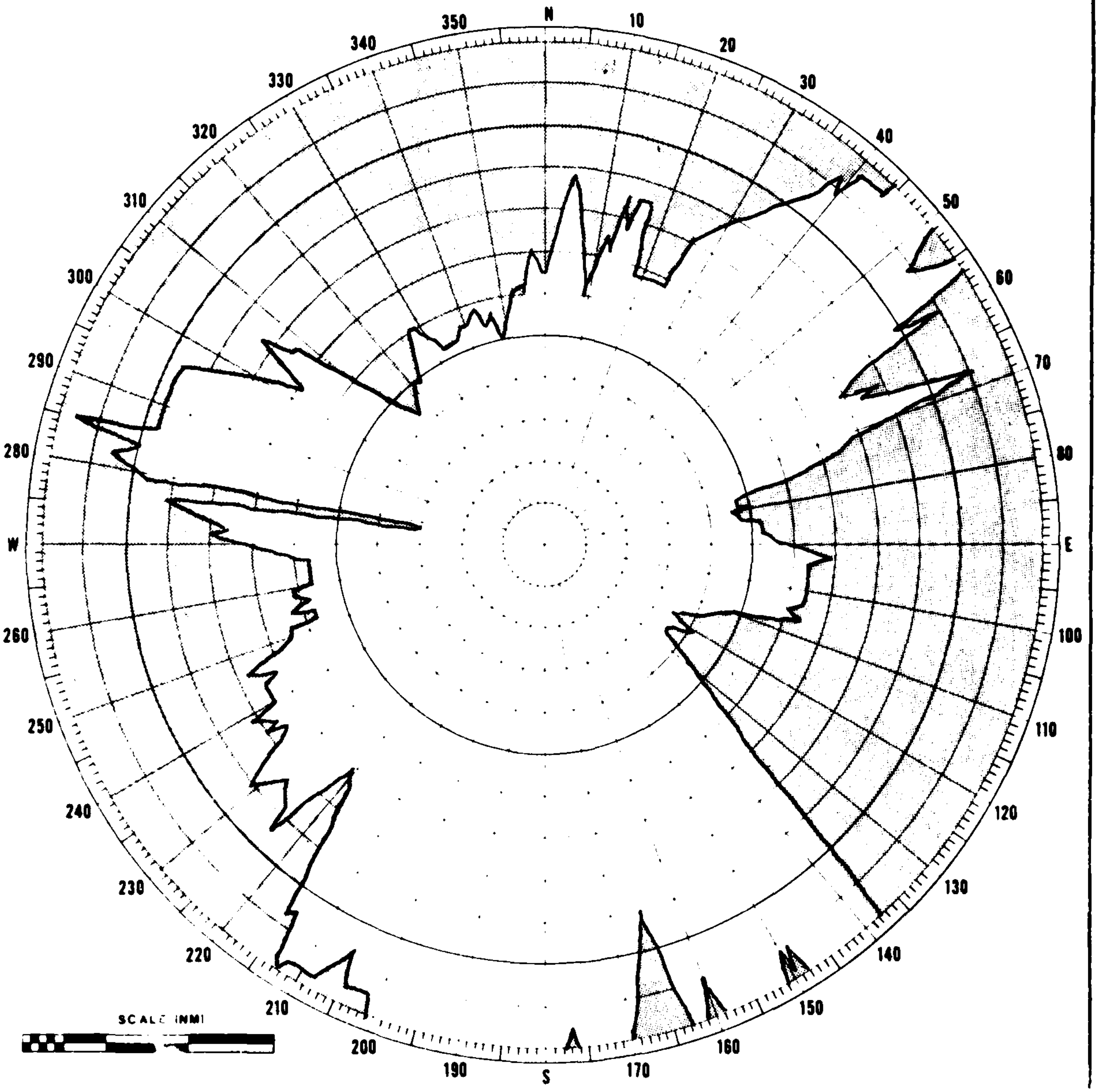
LINE OF SIGHT COVERAGE

LOCATION

Nellis AFB

DATE

January 1980



Indicates area of no coverage due to screening.

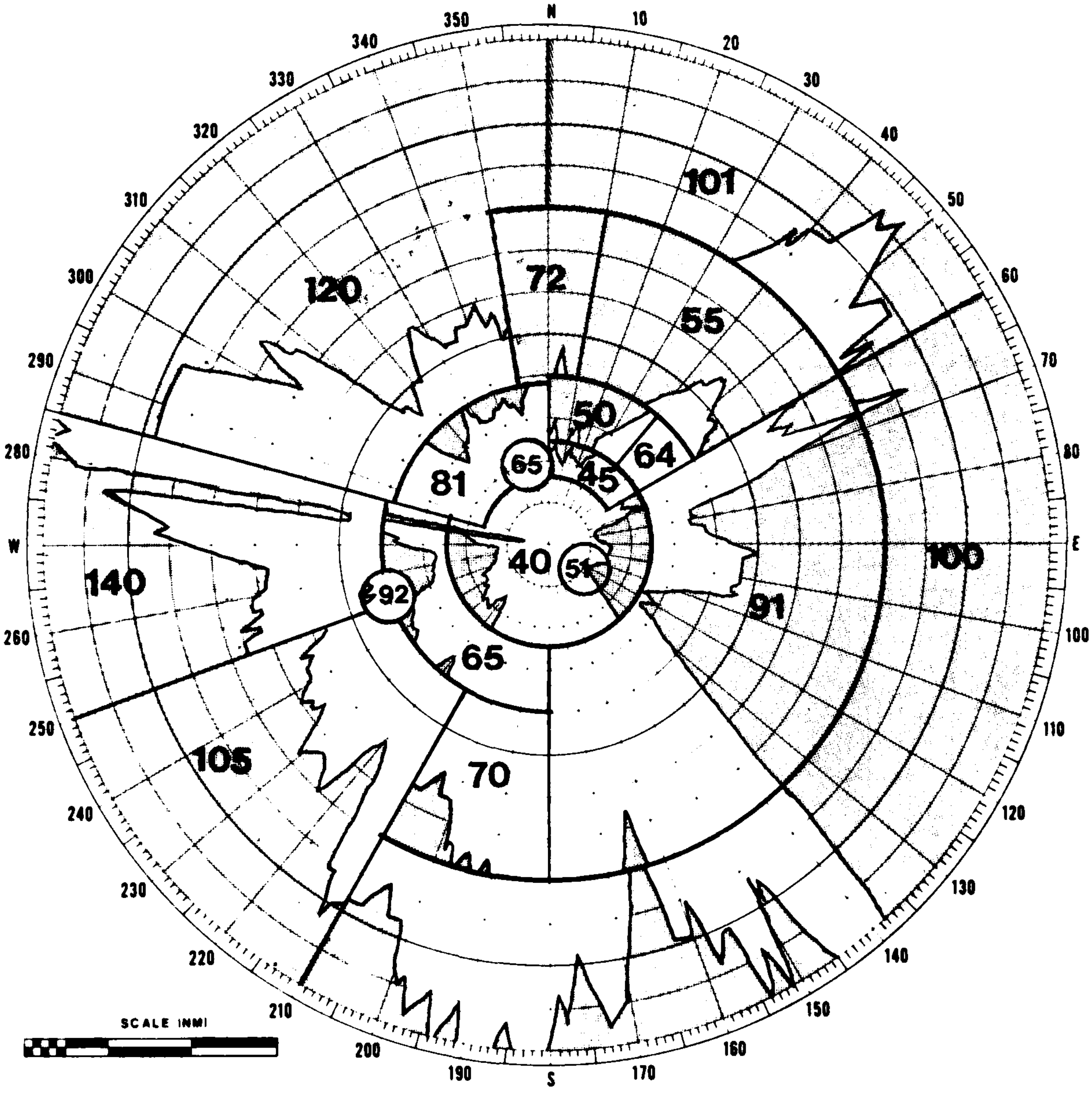
REMARKS

5 NM range marks
12,000 feet MSL

TITLE

SCREENING AT MVA

LOCATION	DATE
Nellis AFB	January 1980



Indicates areas of no coverage due to screening.

REMARKS

5 NM range marks.

TITLE

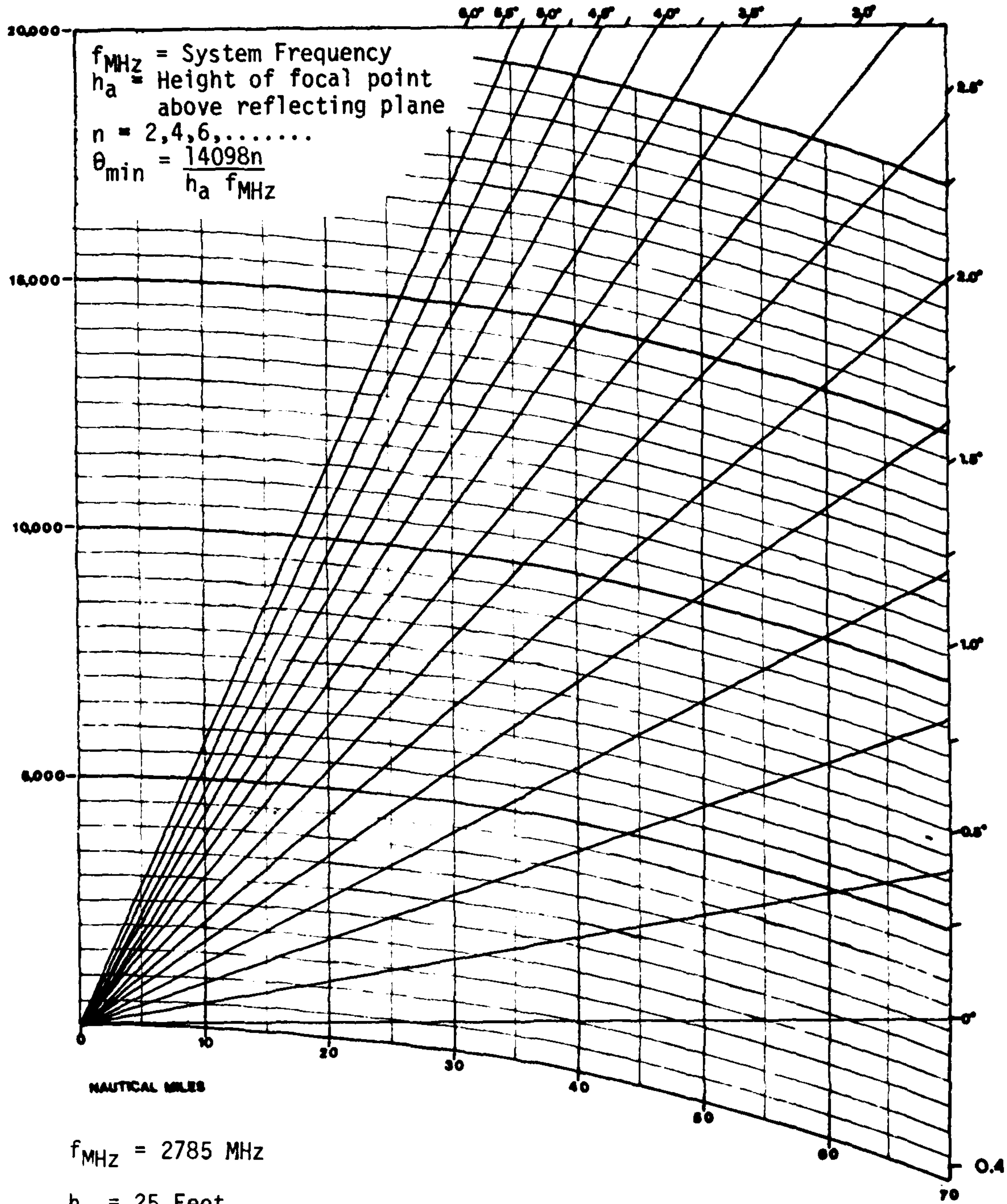
ASR NULL ANGLE PREDICTIONS

LOCATION

Nellis AFB

DATE

January 1980



f_{MHz} = 2785 MHz

h_a = 25 Feet

Channel A

REMARKS

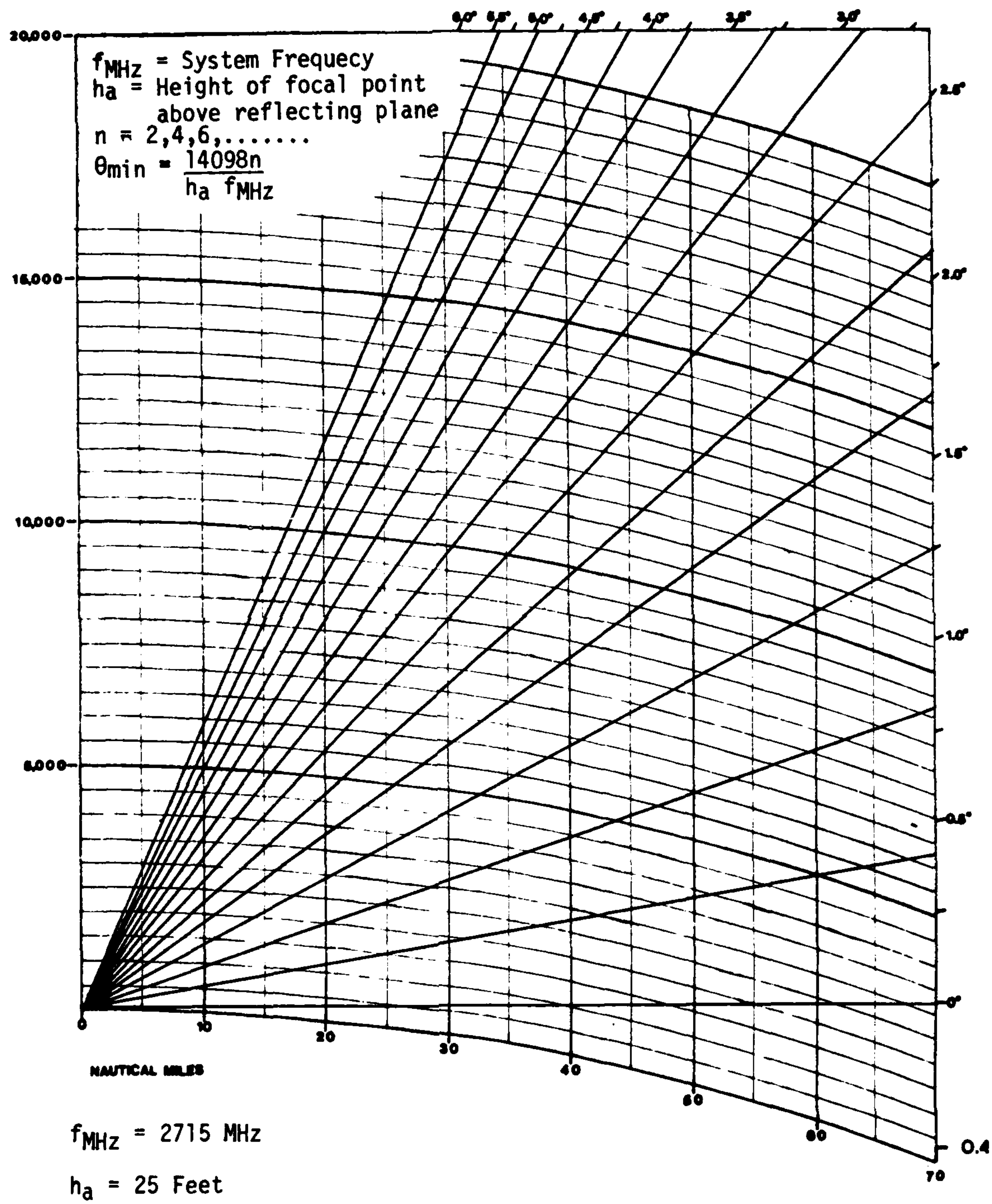
Holes caused by multipath nulling can occur at the range where the null lines cross the aircraft altitude.

TITLE

ASR NULL ANGLE PREDICTIONS

LOCATION: Nellis AFB

DATE: January 1980



f_{MHz} = 2715 MHz

h_a = 25 Feet

Channel B

REMARKS

Holes caused by multipath nulling can occur at the range where the null lines cross the aircraft altitude.

TITLE

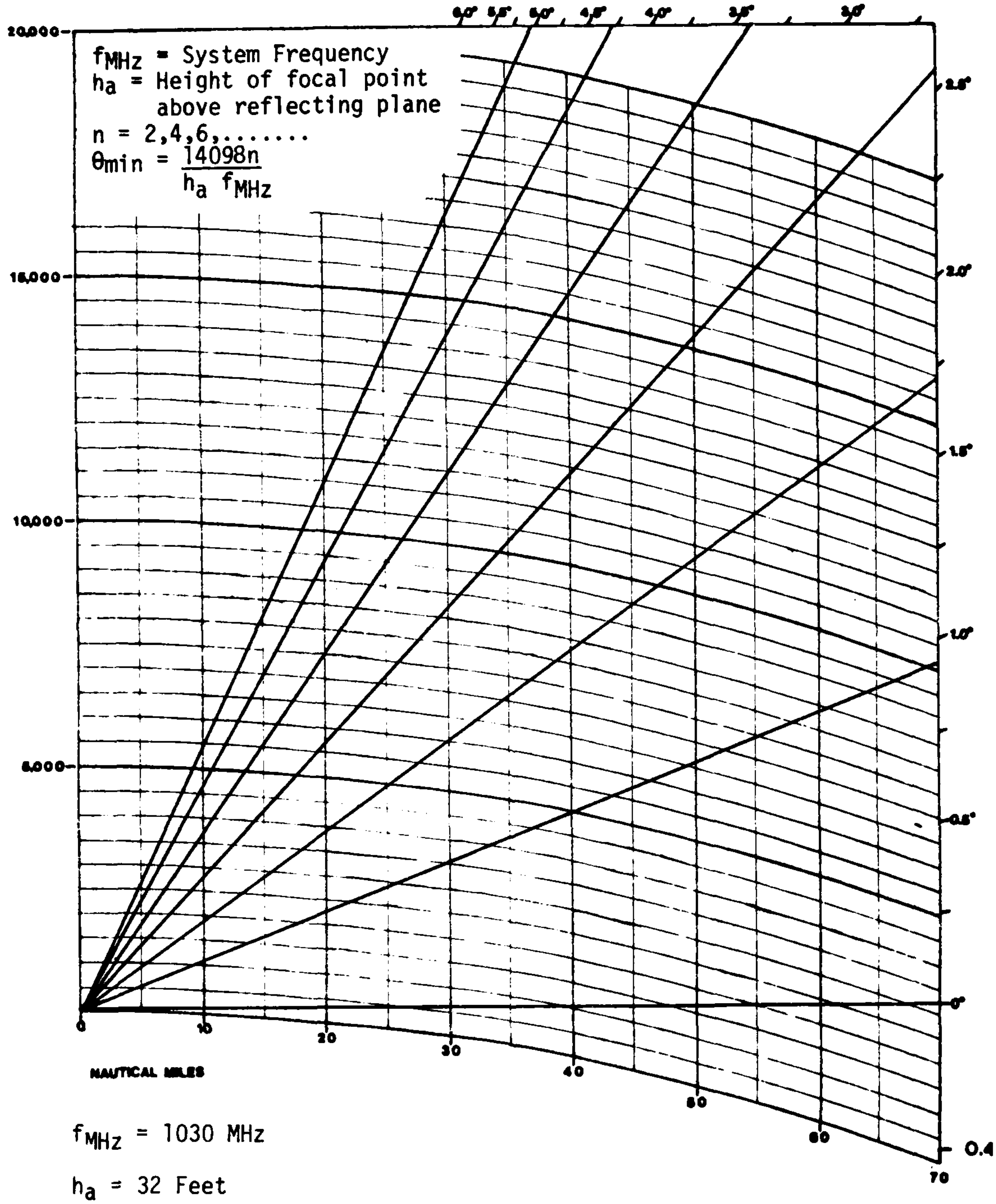
ATCRBS NULL ANGLE PREDICTIONS

LOCATION

Nellis AFB

DATE

January 1980



f_{MHz} = 1030 MHz

h_a = 32 Feet

REMARKS

Holes caused by multipath nulling can occur at the range where the null lines cross the aircraft altitude.

TITLE

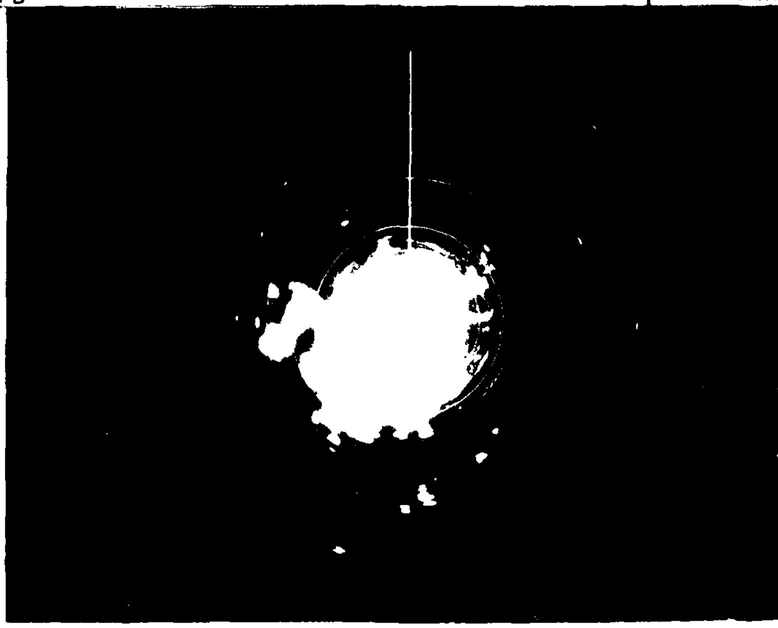
ASR CLUTTER INTENSITY

LOCATION

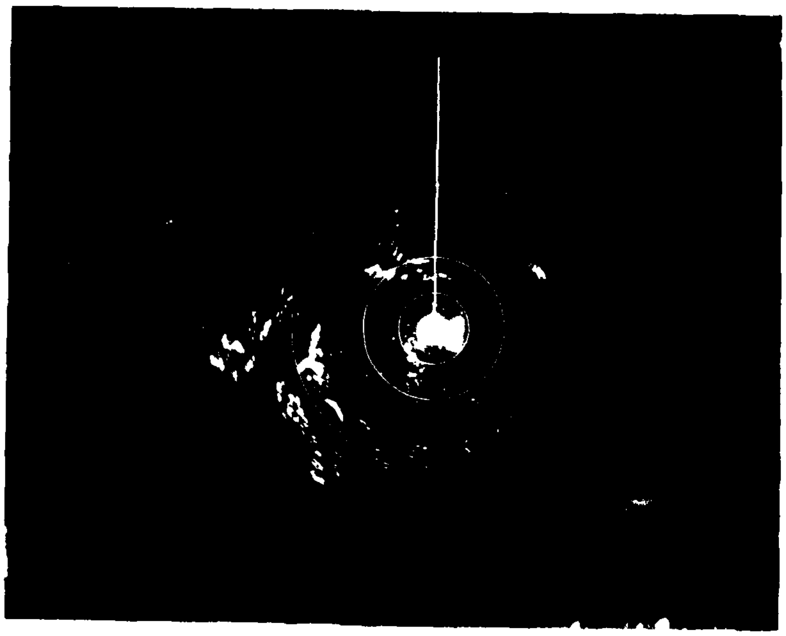
Nellis AFB

DATE

January 1980



0 dB Attenuation



40 dB Attenuation

REMARKS

1. 2° antenna tilt; low beam.
2. 60 NM scope.

TITLE

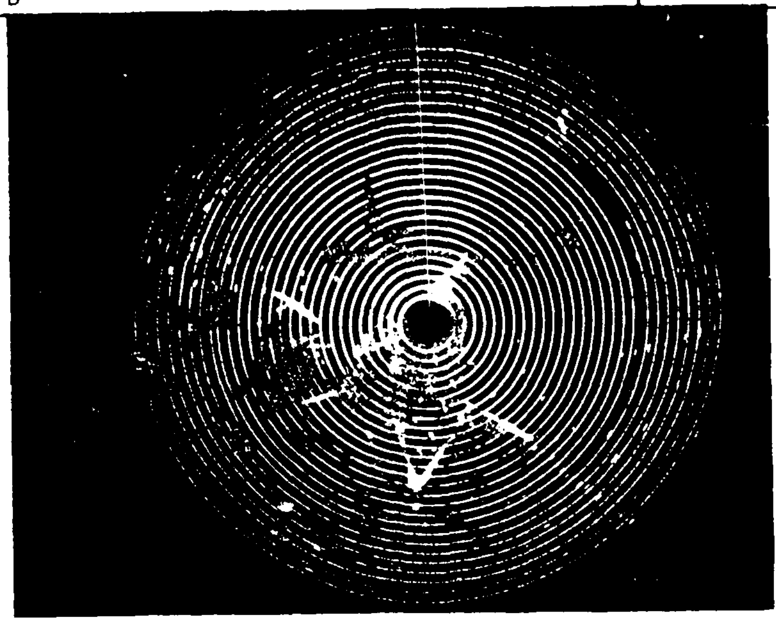
ANNULAR SUBCLUTTER VISIBILITY

LOCATION

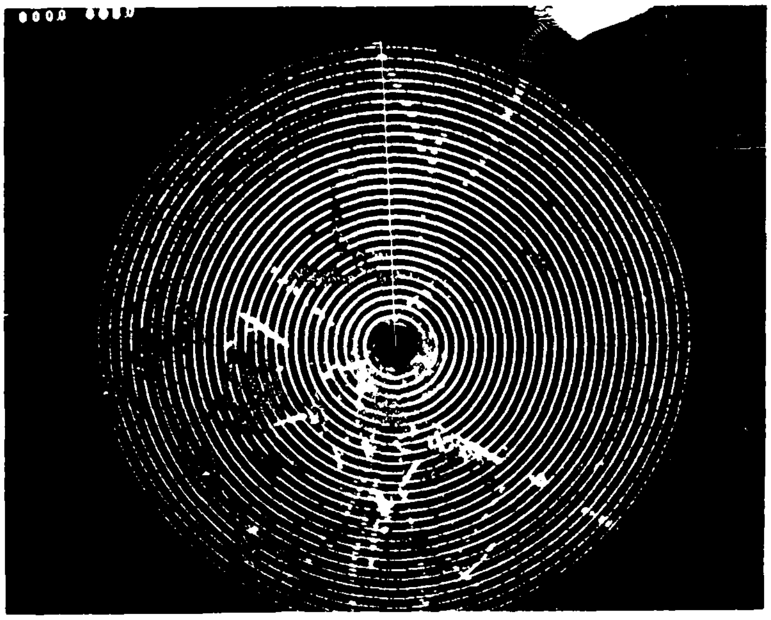
Nellis AFB

DATE

January 1980



1° Tilt



1.5° Tilt

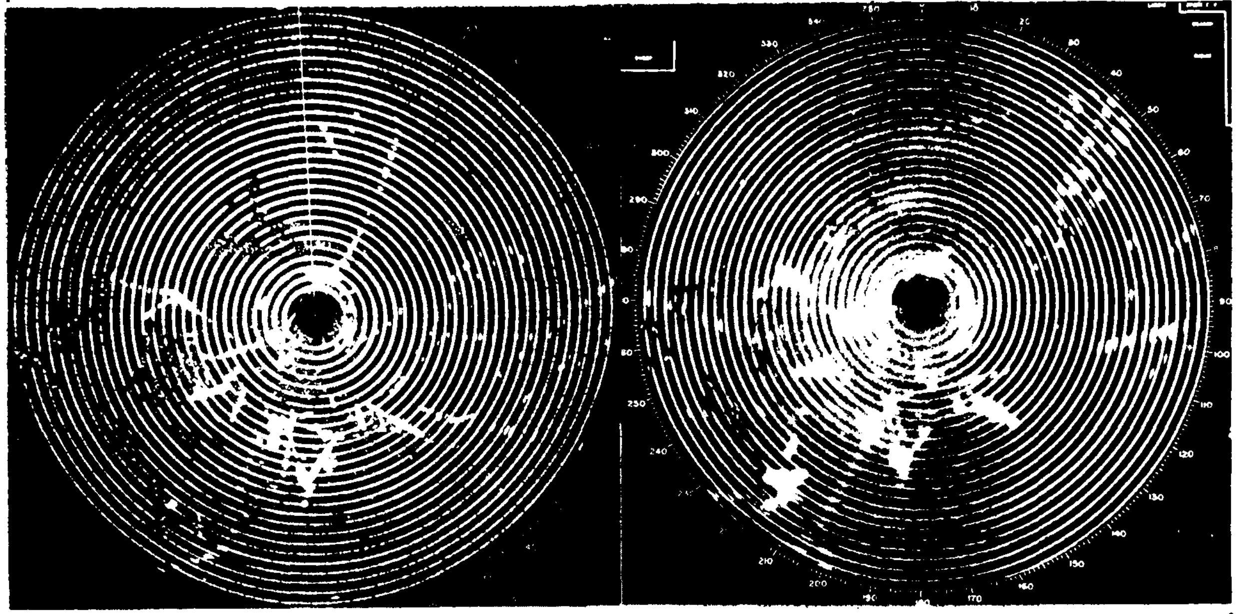
REMARKS

1. Active beam; Enhancer off; Inside ring 3 NM; Outside ring 29 NM.
2. Ring represents signal strength of a C-140 size aircraft.

TITLE

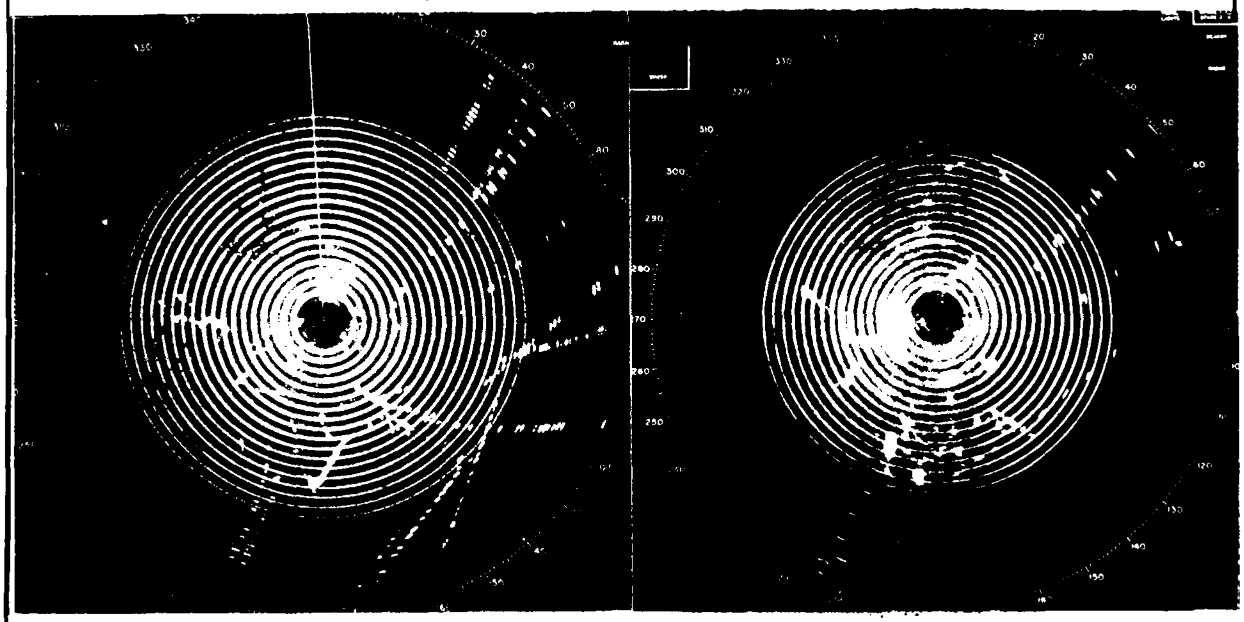
ANNULAR SUBCLUTTER VISIBILITY

LOCATION	DATE
Nellis AFB	January 1980



ENHANCER OFF ENHANCER ON

ACTIVE BEAM, INSIDE RING 3 NM, OUTSIDE RING 29 NM



ENHANCER OFF
INSIDE RING 3 NM
OUTSIDE RING 20 NM

PASSIVE BEAM

ENHANCER ON
INSIDE RING 3 NM
OUTSIDE RING 16 NM

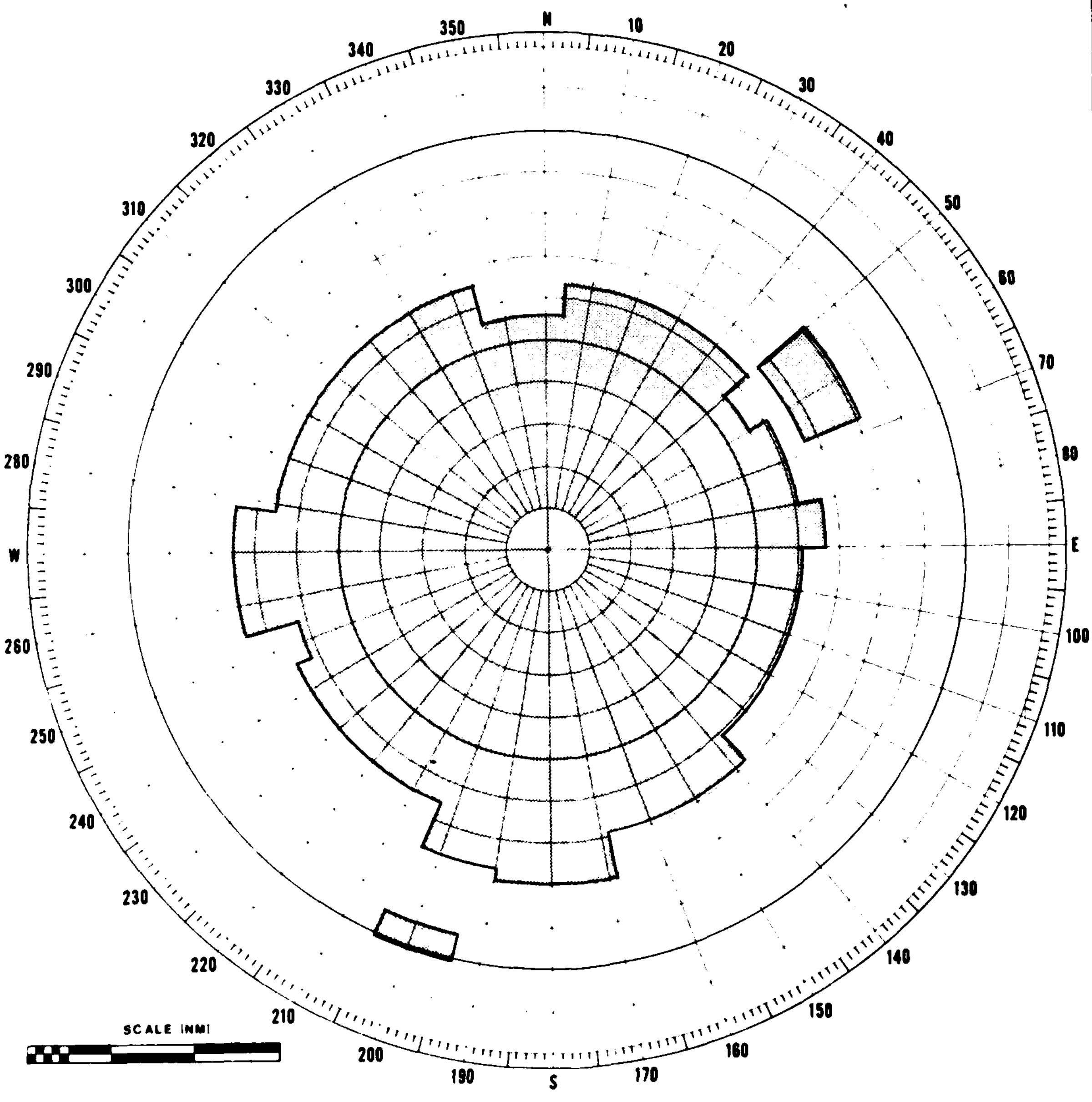
REMARKS

1. 2° Antenna tilt
2. Ring represents signal strength of a C-140 size aircraft

TITLE

MTI RANGE/AZIMUTH GATED AREA

LOCATION	DATE
Nellis AFB	January 1980



Indicates MTI gated area.

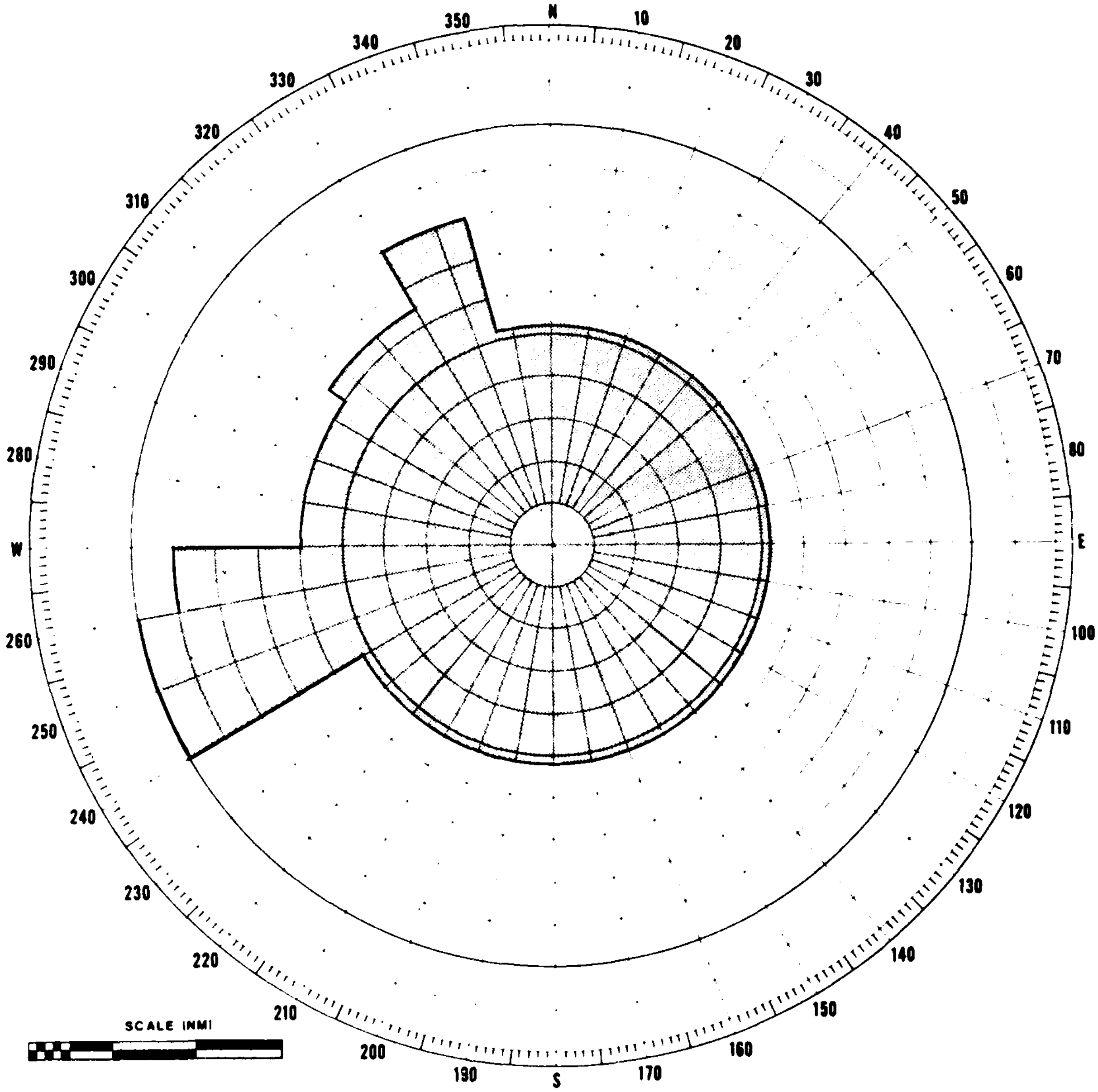
REMARKS

5 NM range marks

TITLE

PASSIVE BEAM GATED AREA

LOCATION	DATE
Nellis AFB	January 1980



Indicates passive beam gated area.

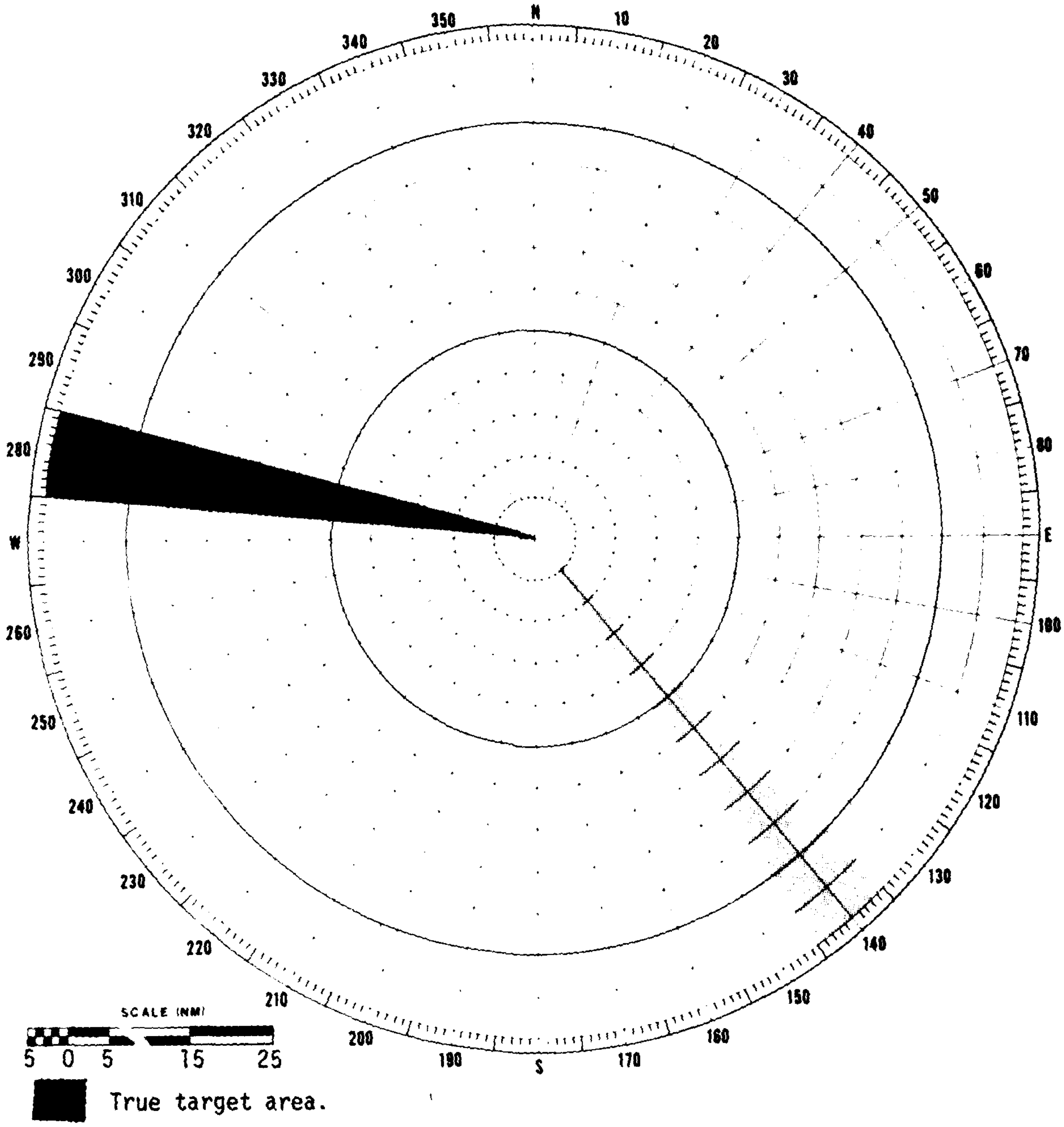
REMARKS

2 NM range marks.

TITLE

POSSIBLE SOURCE OF ATCRBS REFLECTIONS

LOCATION	DATE
Nellis AFB	January 1980



True target area.

False target area due to blast fence.

REMARKS

AFCS FORM MAY 73 906 GENERAL INFORMATION

TITLE

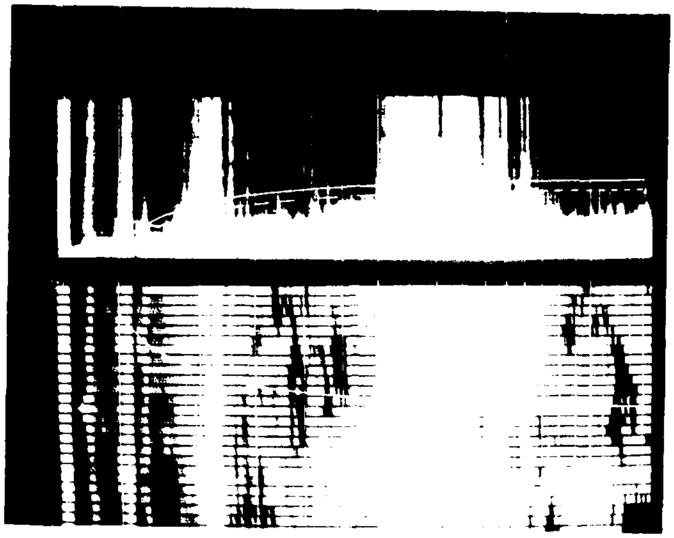
PAR INDICATOR PHOTOGRAPHS

LOCATION

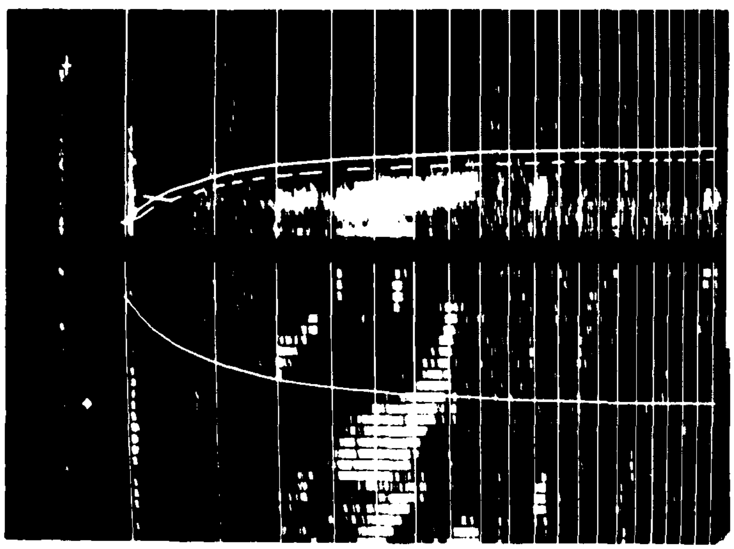
NELLIS AFB

DATE

JANUARY 1980



#1. NORMAL VIDEO PRESENTATION



#2. MTI VIDEO DISPLAY WITH 20NM RANGE

REMARKS

Normal vertical scan.

TITLE

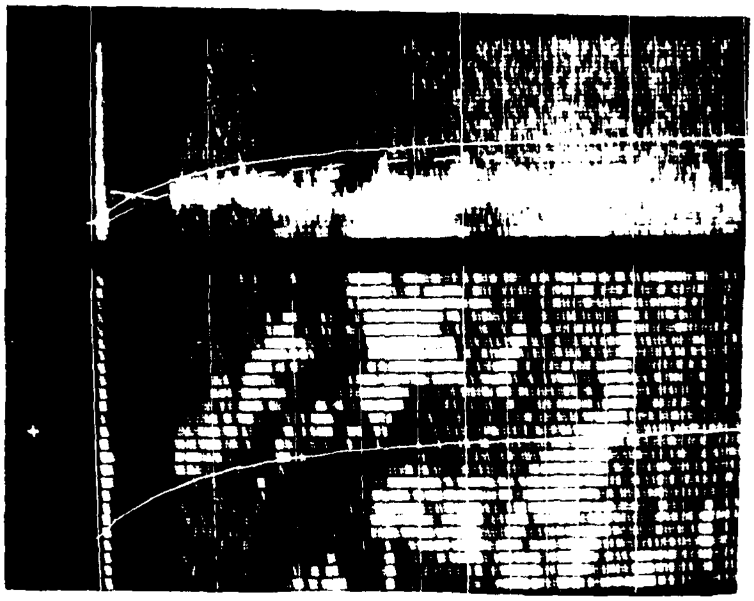
PAR INDICATOR PHOTOGRAPHS

LOCATION

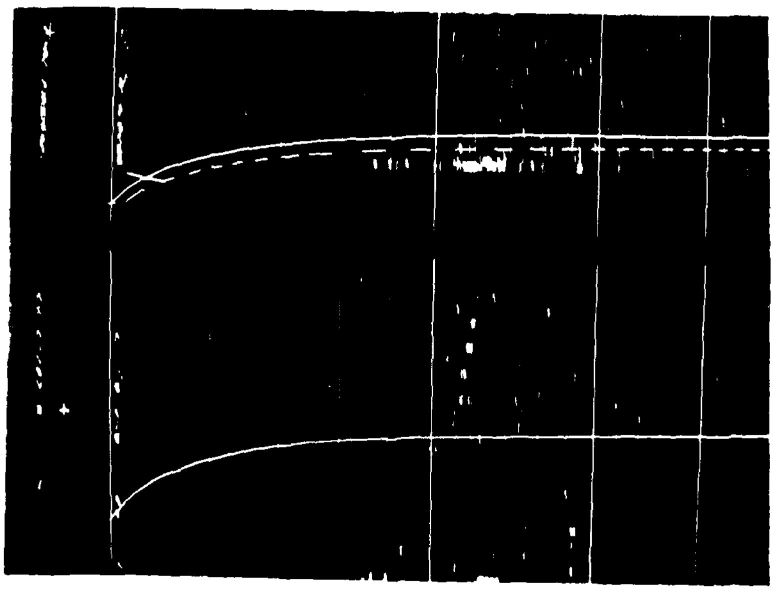
NELLIS AFB

DATE

JANUARY 1980



#3. MTI VIDEO DISPLAY WITH 15NM RANGE NORMAL VERTICAL SCAN



#4. MTI DISPLAY WITH CLIPPED RADIATION PATTERN
MODIFIED VERTICAL SCAN

REMARKS

ASR INITIAL PERFORMANCE CHECKLIST AN/GPN-20

LOCATION Nellis AFB	DATE January 1980
ORGANIZATION 2069 CS	TYPE RADAR/SERIAL NUMBER AN/GPN-20 SN: 925002

SECTION I. ANTENNA SUBSYSTEM

TYPE ANTENNA ASR-8	GROUND ELEVATION 1839 feet MSL
SERIAL NUMBER 925002	HEIGHT TO FOCAL POINT 25 feet AGL

CHECK	SPECIFICATIONS	CHECK RESULTS	
		INITIAL	ADJUSTED
1. Antenna Assembly	*Serial numbers match installation data*	SAT	
2. Pedestal	*Level*	SAT	
3. Feedhorn Alignment	*Telescope cross hairs within tolerance circles*	NOTE 1	
4. Tilt at Lower 3 dB Point	*Mechanical*	1.0	2.0
	Electromagnetic	0.55	1.55
5. Feedhorn Electromagnetic Separation	*Difference between active and passive feedhorns*	3.6	
6. Azimuth Ring Orientation	*Magnetic North 0 ± 0.5 degrees*	UNSAT	SAT
7. Rotation Speed (RPM)	*15 RPM ± 10% at 60 Hz*	16.25	

SECTION II. TRIGGERING SUBSYSTEM

CHECK	SPECIFICATIONS		INITIAL				ADJUSTED			
			A		B		A		B	
	AMPLITUDE	WIDTH	A	W	A	W	A	W	A	W
1. Aligned Pretrigger 3(6)A1A28TP12	*3.5 V Minimum*	*.467 usec Nominal*	3.9	.467	4.0	.467				
2. Aligned Beacon 3(6)A1A28TP19	*3.5 V Minimum*	*.467 usec Nominal*	4.0	.467	4.0	.467				
3. Aligned Zero Range 3(6)A1A28TP14	*3.5 V Minimum*	*.467 usec Nominal*	3.8	.467	4.0	.467				
4. Aligned Display 3(6)A1A28TP18	*3.5 V Minimum*	*.467 usec Nominal*	3.9	.467	3.5	.467				
5. Start Stagger Sequence 3(6)A1A28TP21	*3.5 V Minimum*	*.467 usec Nominal*	4.0	.467	3.8	.467				

SECTION III. TRANSMITTER SUBSYSTEM

CHECK	SPECIFICATIONS	CHECK RESULTS			
		INITIAL		ADJUSTED	
		A	B	A	B
1. PRF	*Nonstagger 1040 PPS*	1040	1040		
	Stagger 1040 PPS	1040	1040		
2. Magnetron Filament Voltage	*Operate: 9.0 ± 1.0 VDC*	9.38	9.00		
	Standby: 17.0 ±1.0 VDC	17.1	17.0		
3. Pulse Width	*0.80 usec* NOTE 2	.88	.86	.88	
4. Magnetron Spectrum	*40 dB Down at f_o ± 13 MHz*	50	48	50	

SECTION III. (Continued) **TRANSMITTER SUBSYSTEM**

CHECK	SPECIFICATIONS	CHECK RESULTS INITIAL A	INITIAL B	ADJUSTED A	ADJUSTED B
5. Transmitter Frequency	*Assigned frequency*	2785	2715	2785	
6. Duty Cycle	*(PW) X (PRF)*	.001	.001	.001	
7. High Voltage	*210 ± 10 volts*	205	205	205	
8. High Voltage Current	*7.5 ± 1.0 AMPS*	6.8	6.6	7.0	
9. Magnetron Current	*38 ma Nominal*	36.0	36.0	36.0	
10. Relative Inverse Figure	< 0.7	.62	.60	.60	

11. Average Power	*56.0 dB Minimum with Stagger on or off*	INITIAL				ADJUSTED			
		A		B		A		B	
		CP	LP	CP	LP	CP	LP	CP	LP
A. Incident Power	*56.0 dB Minimum*	56.7	56.7	56.4	56.4	57.0	57.0		
B. Reflected Power		38.1	37.7	38.2	39.1	39.4	39.2		
C. Difference (A–B)	*15.56 dB Minimum*	18.6	19.0	18.2	17.3	17.6	17.8		
D. VSWR	*1.4:1 Maximum active only*	1.3:1	1.2:1	1.3:1	1.3:1	1.3:1	1.3:1		

SECTION IV. **RECEIVER SUBSYSTEM**

CHECK	SPECIFICATIONS		INITIAL A	INITIAL B	ADJUSTED A	ADJUSTED B
1. AFC Operation	*Proper indication*		SAT	SAT		
2. Pos. Rcvr Crystal Current	*0.6 – 2.4 ma*		.96	1.68		
3. Neg. Rcvr Crystal Current	*0.6 – 2.4 ma*		1.08	1.62		
4. PARAMP Gain	*+15 dB Nominal*		17.5	18.0		
5. Noise Figure	*4.0 dB Maximum*	*ACTIVE*	1.9	2.0		
		PASSIVE	2.65	3.2		
6. Normal Sensitivity	*–110 dBm Minimum*	*ACTIVE*	-110.6	-110.8		
		PASSIVE	-110.6	-110.8		
7. MTI Sensitivity	*–108 dBm Minimum*	*ACTIVE*	-109.6	-110.8		
		PASSIVE	-109.6	-110.8		
8. Normal Log Sensitivity	*–109 dBm Minimum*	*ACTIVE*	-109.6	-109.8		
		PASSIVE	-109.6	-109.8		
9. MTI Log Sensitivity	*–106 dBm Minimum*	*ACTIVE*	-107.6	-108.8		
		PASSIVE	-107.6	-108.8		
10. TR Recovery Time	*5 us Maximum*	*ACTIVE*	3.8	3.0		
		PASSIVE	2.0	2.0		
11. PREAMP Normal — *Bandwidth*	*10 MHz Nominal*		10.0	9.82		
Center Frequency	*30 MHz Nominal*		28.68	29.02		
Gain	*21 dB Minimum*		28	27	25	25

SECTION IV. (Continued) **RECEIVER SUBSYSTEM**

CHECK		SPECIFICATIONS	CHECK RESULTS			
			INITIAL		ADJUSTED	
			A	B	A	B
12. PREAMP MTI	Bandwidth	10 MHz Nominal	10.0	9.82		
	Center Frequency	30 MHz Nominal	28.68	29.02		
	Gain	21 dB Minimum	28	27	25	25
13. Normal IF AMP	Bandwidth	1.2 ± 0.12 MHz	1.17	1.3		
	Center Frequency	30 ± 0.2 MHz	30.01	30.01		
14. MTI IF AMP	Bandwidth	5.0 ± 1.0 MHz	5.47	5.62	5.05	
	Center Frequency	30 MHz Nominal	29.5	30.02	29.78	
15. Normal Log IF	Bandwidth	1.2 ± 0.12 MHz	1.3	1.25		
	Center Frequency	30 ± 0.1 MHz	29.95	29.99		
16. Video Enhancer Gain	Normal	10 dB Minimum	13	13.8		
	MTI	10 dB Minimum	12.8	12.5		
17. Cancellation Radio		40 dB Minimum	40+	40+		
18. Subclutter Visibility		25 dB Minimum	27	28		

19. "A" Channel STC Values	INITIAL				ADJUSTED			
ACTIVE CHANNEL	INIT dB	DELAY usec	SLOPE dB	RECOVY usec	INIT dB	DELAY usec	SLOPE dB	RECOVY usec
STC 1	24	80.24	4	140.0				
STC 2	34	120.4	5	224.3				
STC 3	40	120.4	6	215.1				
PASSIVE CHANNEL								
STC 1	16	24.26	4	39.19				
STC 2	12	40.12	4	47.58				
STC 3	20	0.0	3	94.79				

SECTION IV. (Continued) RECEIVER SUBSYSTEM

20. "B" Channel STC Values	INITIAL				ADJUSTED			
ACTIVE CHANNEL	INIT dB	DELAY usec	SLOPE dB	RECOVY usec	INIT dB	DELAY usec	SLOPE dB	RECOVY usec
STC 1	24	80.24	4	140.0				
STC 2	34	120.4	5	224.3				
STC 3	40	120.4	6	215.1				
PASSIVE CHANNEL								
STC 1	16	24.26	4	39.19				
STC 2	12	40.12	4	47.58				
STC 3	20	0.0	3	94.79				

21. RF Gain NOTE 3	"A" CHANNEL				"B" CHANNEL			
	ACTIVE		PASSIVE		ACTIVE		PASSIVE	
	INITIAL	ADJUST	INITIAL	ADJUST	INITIAL	ADJUST	INITIAL	ADJUST
RF Gain No. 1								
RF Gain No. 2								
RF Gain No. 3		NOTE 3					NOTE 3	
RF Gain No. 4								
RF Gain No. 5								

SECTION V. REMOTING

CHECK	SPECIFICATIONS	CHECK RESULTS									
		AMPLITUDE				WIDTH				DISTORTION	
		INITIAL		ADJUST		INITIAL		ADJUST			
		A	B	A	B	A	B	A	B	A	B
A. Normal Line Driver Input		SAT	SAT			SAT	SAT			SAT	SAT
B. Normal Line Driver Output 3(6)A1A49TP1	5.0 V Nominal 1.0 usec	SAT	SAT			SAT	SAT			SAT	SAT
C. MTI Line Driver Input		SAT	SAT			SAT	SAT			SAT	SAT
D. MTI Line Driver Output 3(6)A1A39TP15	5.0 V Nominal 1.0 usec	SAT	SAT			SAT	SAT			SAT	SAT

SECTION V. (Continued) REMOTING

CHECK	TEST POINT	SPECIFICATIONS	CHECK RESULTS INITIAL	CHECK RESULTS ADJUSTED
A. Normal Line Amplifier Input *	9A1J22		SAT	
B. MTI Line Amplifier Input *	9A1J11		SAT	
C. Normal Line Amplifier Output Comp No. 1	9A2A20TP27	5.0 V Nominal 1usec	SAT	
	9A2A20TP25	5.0 V Nominal 1usec	SAT	
D. Normal Line Amplifier Output Comp No. 2	9A2A21TP27	5.0 V Nominal 1usec	SAT	
	9A2A21TP25	5.0 V Nominal 1usec	SAT	
E. MTI Line Amplifier Output Comp No. 1	9A2A20TP29	5.0 V Nominal 1usec	SAT	
	9A2A20TP31	5.0 V Nominal 1usec	SAT	
F. MTI Line Amplifier Output Comp No. 2	9A2A21TP29	5.0 V Nominal 1usec	SAT	
	9A2A21TP31	5.0 V Nominal 1usec	SAT	

SECTION VI. INDICATOR SUBSYSTEM

1. PPI		ASR 1	ASR 2	ASR 3	ASR 4
A. MDS Differential	0 dB loss between indicator and receiver	SAT	SAT	SAT	NOTE 4
B. Sweep Stability	No sweep jitter and no sweep overlap	SAT	SAT	SAT	NOTE 4
C. Azimuth Orientation	0 ± 1.0 degree from antenna orientation	SAT	SAT	SAT	NOTE 4
2. Range Mark Interval	Verify accuracy with CRT test pattern	SAT	SAT	SAT	NOTE 4
3. Switches and Functions	Satisfactory Orientation	SAT	SAT	SAT	NOTE 4

* The amount of signal loss and distortion is dependent upon the length of the landlines.

NOTE 1: Data filed with the E&I installation team.

NOTE 2: "A" channel magnatron was replaced wich accounts for two sets of "A" channel readings in the transmitter section.

NOTE 3: All RF gains were left at maximum.

NOTE 4: ASR 4 (maintenance indicator) was not aligned.

TECHNICIAN:

TSgt Hurd, TSgt Fisher

CONSOLIDATED SOLAR DATA RECORD

☒ SEARCH RADAR ☐ HEIGHT FINDER RADAR

1. SITE	2. LOCATION	3. POLARIZATION/BEAM	4. TYPE OF EQUIPMENT
2069 CS	Nellis AFB, NV	Linear/Active	AN/GPN-20

DATE A	PEAK TIME (Z) B	MECH TILT (Mils)/(Degrees) C		H_c (Degrees) D	REFRACTION (Degrees) E	TRUE TILT[1] (Degrees) F	TILT OR BORESIGHT[2] ERROR (Degrees) G
13 Dec 79	1518.9		3.5	5.41	.15	5.56	2.06
13 Dec 79	2349.6		3.5	5.40	.15	5.55	2.05
15 Dec 79	1520.4		3.5	5.40	.15	5.55	2.05
15 Dec 79	2350.1		3.5	5.43	.15	5.58	2.08

REMARKS

TOTAL	8.24
AVERAGE	2.06
90% CONFIDENCE VALUES	0.019
INTERVAL	
LIMITS	2.04 TO 2.08

[1] H_c plus refraction equals true tilt.
[2] Mechanical tilt minus true tilt equals tilt error or elevation boresight error.

AF FORM AUG 70 863

79-54380

CONSOLIDATED SOLAR DATA RECORD

☒ SEARCH RADAR ☐ HEIGHT FINDER RADAR

1. SITE	2. LOCATION	3. POLARIZATION/BEAM	4. TYPE OF EQUIPMENT
2069 CS	Nellis AFB, NV	Linear/Passive	AN/GPN-20

DATE A	PEAK TIME (Z) B	MECH TILT (Mils) C	MECH TILT (Degrees) C	H_c (Degrees) D	REFRACTION (Degrees) E	TRUE TILT[1] (Degrees) F	TILT OR BORESIGHT ERROR[2] (Degrees) G
12 Dec 79	2327.54		3.5	8.98	.09	9.07	5.57
13 Dec 79	1539.95		3.5	8.90	.09	8.99	5.49
13 Dec 79	2327.14		3.5	9.10	.09	9.19	5.69
14 Dec 79	2327.72		3.5	9.05	.09	9.14	5.64
14 Dec 79	1542.70		3.5	9.10	.09	9.19	5.69

REMARKS

TOTAL	28.08
AVERAGE	5.62
90% CONFIDENCE VALUES	.09
INTERVAL	
LIMITS	5.53 TO 5.71

[1] H_c plus refraction equals true tilt.
[2] Mechanical tilt minus true tilt equals tilt error or elevation boresight error.

AF FORM AUG 70 863

79-54 (N)

VIDEO MAPPER PERFORMANCE		DATE January 1980	
LOCATION Nellis AFB		ORGANIZATION 2069 CS	
CHECK/FRONT PANEL VOLTMETER	SPECIFICATIONS	CHECK RESULTS	
SECTION I. VIDEO CONVERTER		INITIAL	READJUST
METER POSITION #1	5.0 VDC MAXIMUM	SAT	
METER POSITION #2	5.0 VDC MAXIMUM	SAT	
METER POSITION #3	5.0 VDC MAXIMUM	SAT	
METER POSITION #4	5.0 VDC MAXIMUM	SAT	
METER POSITION #5	5.0 VDC MAXIMUM	SAT	
SECTION II SYNCRO CONVERTER			
SYNCRO CONVERTER #1			
METER POSITION #6	+5.0 TO −5.0 VDC SWING	SAT	
METER POSITION #7	+5.0 TO −5.0 VDC SWING	SAT	
SYNCRO CONVERTER #2			
METER POSITION #6	+5.0 TO −5.0 VDC SWING	SAT	
METER POSITION #7	+5.0 TO −5.0 VDC SWING	SAT	
SECTION III. PRE-TRIGGER			
PRE-TRIGGER CARD #1			
METER POSITION #8	6.0 ± 1 VDC	SAT	
METER POSITION #9	−6.0 ± 1 VDC	SAT	
METER POSITION #10	3.5 ± 1.5 VDC	SAT	
PRE-TRIGGER CARD #2			
METER POSITION #8	6.0 ± 1 VDC	SAT	
METER POSITION #9	−6.0 ± 1 VDC	SAT	
METER POSITION #10	3.5 ± 1.5 VDC	SAT	
SECTION IV. HIGH VOLTAGE POWER SUPPLY			
METER POSITION #11	5.0 ± 1 VDC	SAT	
METER POSITION #11	5.0 ± 1 VDC	SAT	
SECTION V. LOW VOLTAGE POWER SUPPLY			
POWER SUPPLY #1			
METER POSITION #12	16.0 ± 1 VDC	SAT	
METER POSITION #13	−16.0 ± 1 VDC	SAT	
METER POSITION #14	5.0 ± 1 VDC	SAT	
POWER SUPPLY #2			
METER POSITION #12	16.0 ± 1 VDC	SAT	
METER POSITION #13	−16.0 ± 1 VDC	SAT	
METER POSITION #14	5.0 ± 1 VDC	SAT	

CHECK	SPECIFICATION	MAP 1	MAP 2	MAP 3	MAP 4	MAP 5
MAP PRESENTATION	UNIFORM BRIGHTNESS AND CLARITY	SAT	SAT	SAT	SAT	SAT
MAP ALIGNMENT NOTE 1	PROPER CORRELATION OF ECHOS AND MARKERS	UNSAT	UNSAT	UNSAT	UNSAT	SAT

TECHNICIAN (Name) TSgt Fisher

NOTE 1: New maps were ordered.

AFCS FORM SEP 77 959

ATCRBS INITIAL PERFORMANCE CHECKLIST

LOCATION	DATE
Nellis AFB	January 1980
ORGANIZATION	TYPE ATCRBS/SERIAL NUMBER
2069 CS	AN/TPX-42(V), Type III, SN: 085

SECTION I ANTENNA SUBSYSTEM

TYPE ANTENNA GPA-123 RAYDOME
SERIAL NUMBER 103

GROUND ELEVATION	HEIGHT TO FOCAL POINT
1839 feet MSL	32 feet AGL

CHECK	SPECIFICATIONS		CHECK RESULTS INIT		CHECK RESULTS ADJ	
1. VSWR	DIRECTIONAL	1.5:1 MAX	SEE NOTE 4		1.22:1	
2. TRANSMISSION LINE LOSS	DIRECTIONAL	SEE NOTES 1 & 2	3.0 dB			
			IR-1	IR-2	IR-1	IR-2
3. RACK LOSS	DIRECTIONAL	SEE NOTE 3	.75 dB	.75 dB		

SECTION II TRANSMITTER SUBSYSTEM

CHECK	SPECIFICATIONS		INIT IR-1	INIT IR-2	ADJ IR-1	ADJ IR-2
1. PULSE WIDTH	0.8 ± 0.1 usec		.75	.75		
2. FREQUENCY	1030 ± 0.2 MHz		1030	1030		
3. OUTPUT POWER	P-1/3	LOW POWER, 300w MAX. J-5 TSDA	100	100		
	P-2	LOW POWER, 300w NOM. J-5 TSDA	100	100		
4. PULSE SPACING			P-1/2	P-1/3	P-1/2	P-1/3
A. MODE 1	P-1/2	2.0 ± 0.1 usec	2.0	2.0		
	P-1/3	3.0 ± 0.1 usec	3.0	3.0		
B. MODE 2	P-1/2	2.0 ± 0.1 usec	2.0	2.0		
	P-1/3	5.0 ± 0.1 usec	5.0	5.0		
C. MODE 3/A	P-1/2	2.0 ± 0.1 usec	2.0	2.0		
	P-1/3	8.0 ± 0.1 usec	8.0	8.0		
D. MODE C	P-1/2	2.0 ± 0.1 usec	2.0	2.0		
	P-1/3	21.0 ± 0.1 usec	21.0	21.0		
5. PRF			346	346		

SECTION III RECEIVER SUBSYSTEM

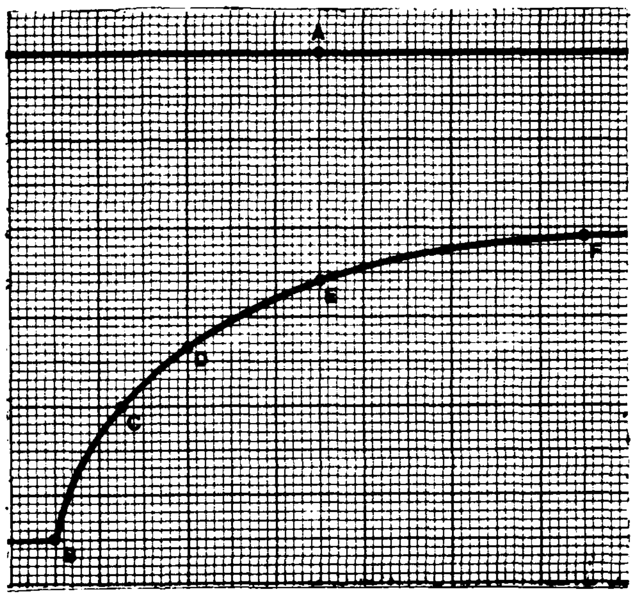
CHECK	SPECIFICATIONS	INIT IR-1	INIT IR-2	ADJ IR-1	ADJ IR-2
1. FREQUENCY	1090 ± 0.3 MHz	1090	1090		
2. Rx GAIN	2.0 ± 0.2 VDC, TP-1, VIDEO LOGIC ONE	2.2	2.2	2.0	2.0
3. Rx SENS	-76 dBm, TP-3, VIDEO PROCESSOR CARD	-80	-79	-79	-76

SECTION III Continued on next page.

SECTION III. RECEIVER SUBSYSTEM		CHECK RESULTS			
		INIT		ADJ	
CHECK	SPECIFICATIONS	ASR-1	ASR-2	ASR-1	ASR-2
4. GTC VOLTAGE	-1.5 VDC NOM, TP-1, VIDEO LOGIC ONE	-1.1	-1.4	-1.5	-1.5
5. GTC DELAY	10 usec NOM, TP-4, VIDEO LOGIC TWO	9.2	9.5	15.0	15.0
6. RECEIVER GATE	2530 usec NOM, TP-3, VIDEO LOGIC ONE	2530	2530		
7. VIDEO LEVEL	5v *Max*, WITH NOISE CLIPPED AT Ø VDC, TP-3, *(VPC)*.	4.0	4.0		

8. GTC CURVE

	IR-1	IR-2
A = Rx SENS =	-79dBm	-76dBm
B = GTC START		
C = 15 usec =	-49dBm	-46dBm
D = 30 usec =	-55dBm	-52dBm
E = 60 usec =	-61dBm	-59dBm
F = 120 usec =	-67dBm	-66dBm



SECTION IV.	VIDEO SIGNAL PROCESSOR	INIT	ADJ
1. WINDOW SIZE	AS DETERMINED BY LOCAL OPERATING REQUIREMENTS	10	
2. WINDOW LEAD EDGE		2	
3. WINDOW TRAIL EDGE		1	
4. CONFIDENCE COUNT		4	3
5. P-MODE / ALL-MODE SWITCH POSITION		All	
6. Δ SWITCH POSITION		±2	
7. AZIMUTH OFFSET COUNT		22	19
8. PRF SWITCH POSITION		<380	
9. PROPER OPERATION OF ALL VSP FUNCTIONS.		SAT	

SECTION V	INDICATOR DATA PROCESSOR	CHECK RESULTS	
CHECK	SPECIFICATIONS	INIT	ADJ
1 ALTITUDE READOUT	MODE READOUT CORRESPONDS TO AIRCRAFT ALTITUDE, ± 50 FT	SAT	
2 REFRESH PERIOD	40 msec PERIOD, AS MEASURED AT A203TP1 *(Nominal)*	SAT	

SECTION VI	INDICATOR FUNCTIONS				
CHECK	SPECIFICATIONS	CHECK RESULTS			
1. EMERGENCY CODES		ASR-1	ASR-2	ASR-3	MAINT
A AURAL ALARM	AUDIBLE TONE AT "A" BOX	SAT	SAT	SAT	SAT
B VISUAL ALARM	INDICATOR DISPLAYS FLASHING SYMBOL	SAT	SAT	SAT	SAT
C LAMP ALARM	"A" BOX DISPLAYS PROPER LAMP INDICATION	SAT	SAT	SAT	SAT
2 ALTITUDE FILTER	AS SELECTED BY "A" BOX CONTROL LIMITS	SAT	SAT	SAT	SAT
3 FORMAT VIDEO	LEGIBILITY REMAINS CONSTANT FROM MAX TO MIN SETTING	SAT	SAT	SAT	SAT
4 TARGET SYMBOL	SAT TARGET INTENSITY COINCIDENT WITH RADAR VIDEO	SAT	SAT	SAT	SAT
5 TARGET TRAIL DOTS	TARGET SYMBOL *(X or O)* WITH A MAX OF THREE TRAIL DOTS	SAT	SAT	SAT	SAT
6. DISCREET CODES	COMPLETE ISOLATION OF SELECTED CODES	SAT	SAT	SAT	SAT
7. BRACKET VIDEO	COINCIDENT WITH RADAR VIDEO	SAT	SAT	SAT	SAT
8 FORMAT POSITION	FORMAT COINCIDES WITH N-E-W-S SWITCH POSITION	SAT	SAT	SAT	SAT

NOTE 1 – FROM J-4/5 ON TOP OF OX-16 CABINET TO ANTENNA INPUT JACKS.

NOTE 2 – TYPE OF CABLE NORMALLY USED, AND RESPECTIVE LOSSES ARE
RG-142, 50 OHMS, 12 dB PER 100 FEET.
RG-255, 50 OHMS, 3 dB PER 100 FEET.
RG-333, 50 OHMS, 3 dB PER 100 FEET

NOTE 3 – FROM J-4, REAR OF IR UNIT, TO J-5 on the back of the TSDA.

REMARKS

NOTE 4: VSWR was unreadable due to bad connector pins at both ends of the transmission line.

TECHNICIAN: SSgt Zeigler

AFCS FORM 903

78-50774

PAR INITIAL PERFORMANCE CHECKLIST GPN 22

SITE	SERIAL NUMBER	DATE
Nellis AFB	18	January 1980

SECTION I — ANTENNA SUBSYSTEM

ANTENNA SERIAL NUMBER	GROUND ELEVATION	HEIGHT TO FOCAL POINT
23	1843 feet MSL	7.5 feet AGL

CHECK	SPECIFICATION	INITIAL	ADJUSTED
1. VERTICAL SENSOR	ANGLE LESS THAN 0.011°	.01098	
2. ABPC PHASE SHIFTER POLL	LESS THAN 20 FAILED SHIFTERS	2	
3. ALGORITHM TEST	SATISFACTORY COMPLETION OF TEST	SAT	
SECTION II	**TARGET DATA COMPUTER**		
DIAGNOSTIC TAPE	SATISFACTORY COMPLETION OF TESTS	SAT	
SECTION III	**SYSTEM PERFORMANCE TESTS**		
1. ANGLE ERROR DETECTOR TESTS	HISTORY DATA WITHIN CURSOR LIMITS — AZ	SAT	
	HISTORY DATA WITHIN CURSOR LIMITS — EL	SAT	
2. RANGE ERROR TEST	SAT COMPLETION OF TEST	SAT	
3. ABPC ROM TEST	SAT COMPLETION OF TEST	SAT	
SECTION IV	**RECEIVER SUBSYSTEM**		
1 METER READINGS			
A. FREQUENCY GENERATOR	METER READINGS IN GREEN AREA	SAT	
B. CRYSTAL CURRENT	METER READINGS IN GREEN AREA	SAT	
C. ANGLE TRACK RECEIVER	METER READINGS ON BLACK CENTERLINE	SAT	
D. RANGE TRACK RECEIVER	METER READINGS IN GREEN AREA	SAT	
E. SCAN RECEIVER	METER READINGS ON BLACK CENTERLINE	SAT	
2. MINIMUM DISCERNABLE SIGNAL			
A. XOAF1 — NORMAL	-100 TO -120 dB	-107	
A. XOAF1 — COHERENT MTI	-97 TO -117 dB	-104	
A. XOAF1 — NONCOHERENT MTI	-95 TO -115 dB	-102	
B. XOBF2 — NORMAL	-100 TO -120 dB	-107	
B. XOBF2 — COHERENT MTI	-97 TO -117 dB	-104	
B. XOBF2 — NONCOHERENT MTI	-95 TO -115 dB	-104	
3 SUBCLUTTER VISIBILITY	24 dB MINIMUM	25	

REMARKS

Attachment 18

SECTION V	TRANSMITTER SUBSYSTEM		
1. VOLTAGE READINGS (*High Power Only*)			
A. 5 V	5 ± 0.5 VDC	+5.2	
B. -5 V	-5 ± 0.5 VDC	-5.2	
C. 12 V	12 ± 1.2 VDC	+12	
D. -12 V	-12 ± 1.2 VDC	-12	
E. 24 V	24 ± 1.2 VDC	23.8	
F. 28 V	28 ± 2.8 VDC	30	
G. STANDBY CONVERTER DCx100	280 ± 28 VDC	280	
H. CFA CONVERTER DCx100	280 ± 28 VDC	330	300
I. CFA HVPS x1K	7.8 ± 0.3 KVA	7.5	
J. THYRATRON BIAS	-20 ± 2.0 VDC	-19	
K. TRIGGER PS x10	200 ± 20 VDC	185	
L. THYRATRON FILAMENT AND RSVR	6.3 ± 0.18 VDC	6.48	6.25
M. TWT HVPS x1K	-24 ± 2.4 KVDC	23.9	
N. ION PUMP	3.8 ± 0.4 KVDC	4.0	
2. CURRENT READINGS. (*High Power Only*)			
A. TWT BODY	4.0 ± 1.0 mA	3.5	
B. CFA MOD SHUNT	40 ± 10 mA	30	
C. CFA	70 ± 17.5 mA	55	
D. CFA HVPS x100	400 ± 100 mA	320	
3. SPLIT PULSE	PULSES PEAKS WITHIN 3 dB OF EACH OTHER	SAT	
4. CHIRP FREQUENCY	120 MHz ± 10% AT 3 dB POINTS	120	
5. AVERAGE POWER OUTPUT	LOW - 30 W (44.8 dBm) MINIMUM	47.4	
	HIGH - 777 W (59.0 dBm) MINIMUM	60.0	
6. PULSE WIDTH	1.0 US ± 10% AT 3 dB POINTS	1.0	
7. PEDESTAL LENGTH	110 NS, -5 TO +15 NS	110	
8. PULSE DELAY	2.30 ± 0.01 US	2.3	

REMARKS

Technicans: TSgt Bryant, TSgt Innis

ASR AC POWER			EQUIPMENT/SERIAL NUMBER: AN/GPN-20 SN 925002		
LOCATION: Nellis AFB				DATE: January 1980	
TRANSMITTER SITE					
LINE VOLTAGE					
CHECK	SPECIFICATIONS	A INITIAL	A ADJUSTED	B INITIAL	B ADJUSTED
"A" PHASE	105 TO 130 VAC	120	NA		
"B" PHASE	105 TO 130 VAC	120	NA		
"C" PHASE	105 TO 130 VAC	120	NA		
REGULATOR OUTPUT					
"A" PHASE	120 VAC	120	NA		
"B" PHASE	120 VAC	120	NA		
"C" PHASE	120 VAC	120	NA		
GENERATOR NOTE 1	MANUFACTURER	TYPE		SERIAL NUMBER	
	CAPACITY	FREQUENCY			
AUTOMATIC CHANGEOVER	MANUFACTURER	TYPE			
REMOTE SITE					
LINE VOLTAGE					
"A" PHASE	105 TO 130 VAC	NA	NA		
"B" PHASE	105 TO 130 VAC	NA	NA		
"C" PHASE	105 TO 130 VAC	NA	NA		
REGULATOR OUTPUT					
"A" PHASE	120 VAC	120	NA		
"B" PHASE	120 VAC	120	NA		
"C" PHASE	120 VAC	120	NA		
GENERATOR NOTE 1	MANUFACTURER	TYPE		SERIAL NUMBER	
	CAPACITY	FREQUENCY			
AUTOMATIC CHANGEOVER	MANUFACTURER	TYPE			

REMARKS:

NOTE 1. Information for generator and changeover panel was not available.

TECHNICIAN *(Name)*: TSgt Hurd, TSgt Fisher

PAR AC POWER	EQUIPMENT/SERIAL NUMBER AN/GPN-22 SN 18
LOCATION Nellis AFB	DATE January 1980

TRANSMITTER SITE

LINE VOLTAGE

CHECK	SPECIFICATIONS	A INITIAL	A ADJUSTED	B INITIAL	B ADJUSTED
"A" PHASE	105 TO 130 VAC	120	NA		
"B" PHASE	105 TO 130 VAC	120	NA		
"C" PHASE	105 TO 130 VAC	120	NA		
REGULATOR OUTPUT					
"A" PHASE	120 VAC	120	NA		
"B" PHASE	120 VAC	120	NA		
"C" PHASE	120 VAC	120	NA		

GENERATOR	MANUFACTURER Fermont	TYPE MB-17	SERIAL NUMBER 72-2139
	CAPACITY 60 kW	FREQUENCY 60 Hz	
AUTOMATIC CHANGEOVER	MANUFACTURER Lake Shore Electric	TYPE EMU Series	

REMOTE SITE

LINE VOLTAGE

CHECK	SPECIFICATIONS	A INITIAL	A ADJUSTED	B INITIAL	B ADJUSTED
"A" PHASE	105 TO 130 VAC	120	NA		
"B" PHASE	105 TO 130 VAC	120	NA		
"C" PHASE	105 TO 130 VAC	120	NA		
REGULATOR OUTPUT					
"A" PHASE	120 VAC	120	NA		
"B" PHASE	120 VAC	120	NA		
"C" PHASE	120 VAC	120	NA		

GENERATOR NOTE 1	MANUFACTURER	TYPE	SERIAL NUMBER
	CAPACITY	FREQUENCY	
AUTOMATIC CHANGEOVER	MANUFACTURER	TYPE	

REMARKS:

NOTE 1: Information for generator and changeover panel was not available.

TECHNICIAN (Name) TSgt Innis

AFCS FORM SEP 77 908A

PREFLIGHT AND POST FLIGHT EQUIPMENT LOG

LOCATION	ORGANIZATION	TECHNICIANS
Nellis AFB, NV	2069 CS	TSgt Fisher

	POWER		NOTE: 1 NORMAL RECEIVER SENSITIVITY		MTI RECEIVER SENSITIVITY NOTE: 1	
DATE	PREFLIGHT	POST FLIGHT	PREFLIGHT	POST FLIGHT	* PREFLIGHT	POST FLIGHT
ASR	Specs 56.0 dbm Min		Specs NORM -110 LOG -109 dbm Min		Specs MTI -108 LOG -106 dbm Min	
B Channel 26 Jan 80	56.3	56.3	NORM -110 LOG -110	NORM -110 LOG -110	MTI -110 LOG -108	MTI -110 LOG -108
B Channel 27 Jan 80	56.4	56.4	NORM -110 LOG -110	NORM -110 LOG -110	MTI -110 LOG -108	MTI -110 LOG -108
B Channel 28 Jan 80	56.4	56.4	NORM -110 LOG -110	NORM -110 LOG -110	MTI -110 LOG -108	MTI -110 LOG -108
A Channel 01 Feb 80	56.2	56.2	NORM -110 LOG -110	NORM -110 LOG -110	MTI -110 LOG -108	MTI -110 LOG -108
B Channel 01 Feb 80	56.4	56.4	NORM -110 LOG -110	NORM -110 LOG -110	MTI -110 LOG -108	MTI -110 LOG -108
IFF/SIF	Specs 300W Max		Specs -76 dbm Min			
26 Jan 80	100W	100W	-79	-79		
27 Jan 80	100W	100W	-79	-79		
28 Jan 80	100W	100W	-79	-79		
01 Feb 80	100W	100W	-79	-79		
PAR NOTE 2	Specs Low Power 44.8 dbm Min		Specs -100 - -120 dbm Min		Specs -97 - -117 dbm Min	
			AF1/BF2	AF1/BF2	AF1/BF2	AF1/BF2
02 Feb 80	45.8	45.8	-106/-108	-106/-108	-101/-106	-101/-106
02 Mar 80	45.0	45.0	-106/-108	-106/-108	-104/-101	-104/-101
04 Mar 80	45.1	45.1	-106/-108	-106/-108	-101/-101	-101/-101
05 Mar 80	45.0	45.0	-106/-108	-106/-108	-104/-101	-104/-101

REMARKS

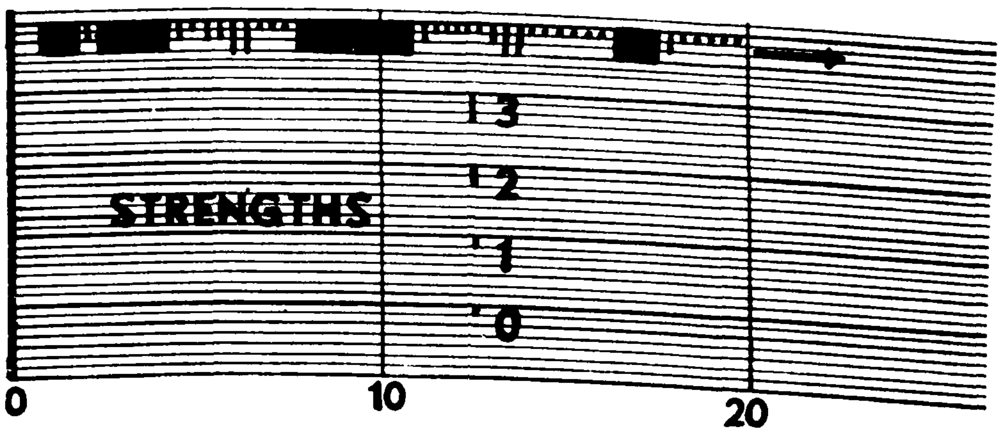
NOTE 1: Sensitivity readings were obtained from both active and passive beams and were identical.

NOTE 2: PAR noncoherent MTI was inoperative during the evaluation.

TITLE

INTERPRETATION OF TRACKING COMPUTATIONS AND 4/3 EARTH CURVATURE GRAPH

Reference AFCS Forms 918 and 916A. Fine grain data presents target strength information in a bar graph format. The figure is an example of a fine grain data track. Target strengths are recorded IAW AFM 55-8. Three or more consecutive misses (strength one targets are counted as misses) constitute a radar hole. The number of scans per a given 5 NM distance will vary as a function of aircraft speed. Each scan of the antenna is presented as a vertical line one, two, or three units high, depending upon the scan signal strength. If the scan signal strength is zero, a dot is depicted. Tracks that are blocked consist of three or more consecutive "three" value scans. Arrows indicate aircraft direction.



DEFINITIONS:

a. BLIP: Refers to the return signal reflected from the aircraft.

b. SCAN: One complete revolution of the antenna.

c. BLIP SCAN RATIO (BSR): Total number of strength 3 and 2 blips divided by the total number of scans.

d. AVERAGE TARGET STRENGTH (ATS):

$$ATS = \frac{(3 \text{ X } a) + (2 \text{ X } b) + (1 \text{ X } c)}{\text{Total Scans}}$$

where a = Total number of strength three targets
b = Total number of strength two targets
c = Total number of strength one targets

e. MAXIMUM OUTER RANGE: The center of the last 10 scans that contain 5 usable returns, i.e. a 50% BSR.

REMARKS

DETECTION/TRACKING DATA

LEGEND: SEE ATTACHMENT A21-8

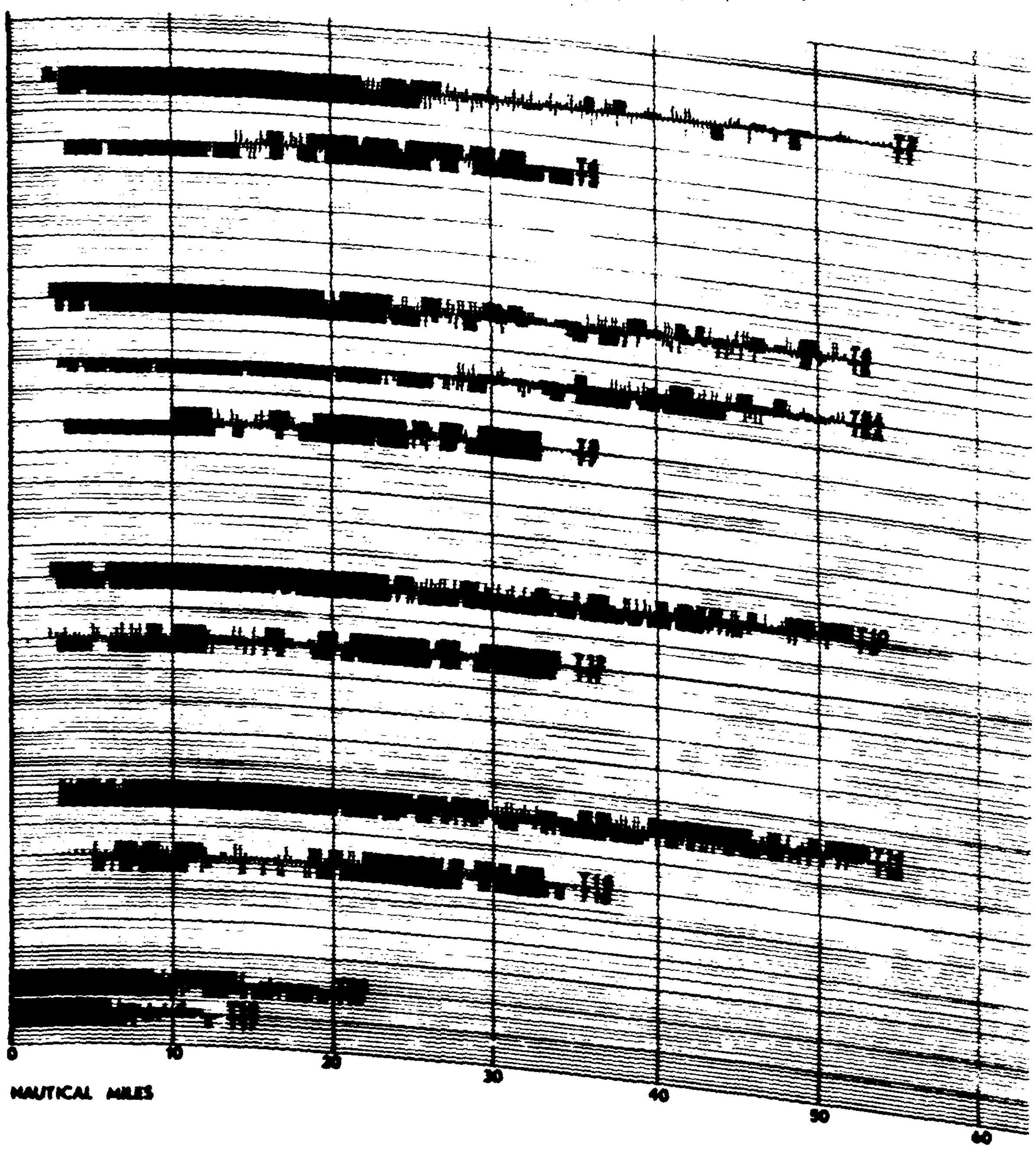
1. LOCATION: Nellis AFB
2. TYPE RADAR: AN/GPN-20
3. MTI GATE: 35 NM
4. TYPE AIRCRAFT: C-140
5. DATE: January 1980

TRACK NO.	TIME (L)	ALT ABOVE FIELD AGL	ASPECT	MECH TILT	SELECTIBLE FEATURES	DETECTION RANGE		REF RANGE NM	DIF FROM REFERENCE		OUTER RNG AZIMUTH	TRACKING							ATCRBS		REMARKS
						INNER	OUTER		NM	dB		WITHIN MTI		OUTSIDE MTI		OVERALL		QUALITY	BSR %	OUTER RANGE	
												ATS	BSR	ATS	BSR	ATS	BSR				
TILT DETERMINATION																					
1	0902	6500	A	2.5	B,G	3.0	44	42	+2		045	2.54	83	1.19	36	2.21	72	C			
2	0917	6500	F	2.5	B,G	2.5	41	42	-1		045	2.47	79	1.52	48	2.17	74	C			
3	0943	10600	A	2.5	B,G	3.5	33	34	-1		255	2.75	91			2.75	91	D			NOTE 1
4	0956	10600	F	2.5	B,G	14	33	34	-1		255	2.63	84			2.63	84	D			NOTE 1
5	1006	6500	A	2.0	B,G	3.0	45	47	-2		045	2.44	80	1.56	44	2.24	72	C			
6	1023	6500	F	2.0	B,G	2.5	51	47	+4		045	2.67	87	1.92	58	2.43	77	C			
7	1039	10600	A	2.0	B,G	3.5	35	34	+1		255	2.42	79			2.42	79	D			NOTE 1
8	1050	10600	F	2.0	B,G	10	35	34	+1		255	2.48	81			2.48	81	D			NOTE 1
9	1100	6500	A	1.5	B,G	3.0	46	50	-4		045	2.88	95	2.53	83	2.79	92	C			NOTE 1
10	1115	6500	F	1.5	B,G	2.5	52	50	+2		045	2.64	87	2.18	69	2.49	81	C			NOTE 1
11	1133	10600	A	1.5	B,G	3.0	34	34	0		255	2.31	74			2.31	74	D			NOTE 1
12	1145	10600	F	1.5	B,G	6.0	34	34	0		255	2.21	69			2.21	69	D			NOTE 1
13	1418	6500	A	1.0	B,G	3.0	50	50	0		045	2.69	90	2.47	83	2.63	88	C			NOTE 1
14	1436	6500	F	1.0	B,G	3.0	53	50	+3		045	2.74	94	2.50	81	2.66	90	C			NOTE 1
15	1449	10600	A	1.0	B,G	5.0	33	34	-1		255	2.24	72			2.24	72	D			NOTE 1
16	1502	10600	F	1.0	B,G	6.0	33	34	-1		255	2.23	72			2.23	72	D			NOTE 1
5A	1513	6500	A	2.0	B,G	3.0	45	47	-2		045	2.56	85	2.55	84	2.56	85	C			
6A	1529	6500	F	2.0	B,G	30					045			2.03	64			C			NOTE 2

TITLE

TILT DETERMINATION COVERAGE CHART

LOCATION	DATE
Nellis AFB	January 1980



REMARKS

DETECTION/TRACKING DATA

LEGEND: SEE ATTACHMENT A21-8

1. LOCATION	2. TYPE RADAR	3. MTI GATE	4. TYPE AIRCRAFT	5. DATE
Nellis AFB	AN/GPN-20	32 NM	C-140	January 1980

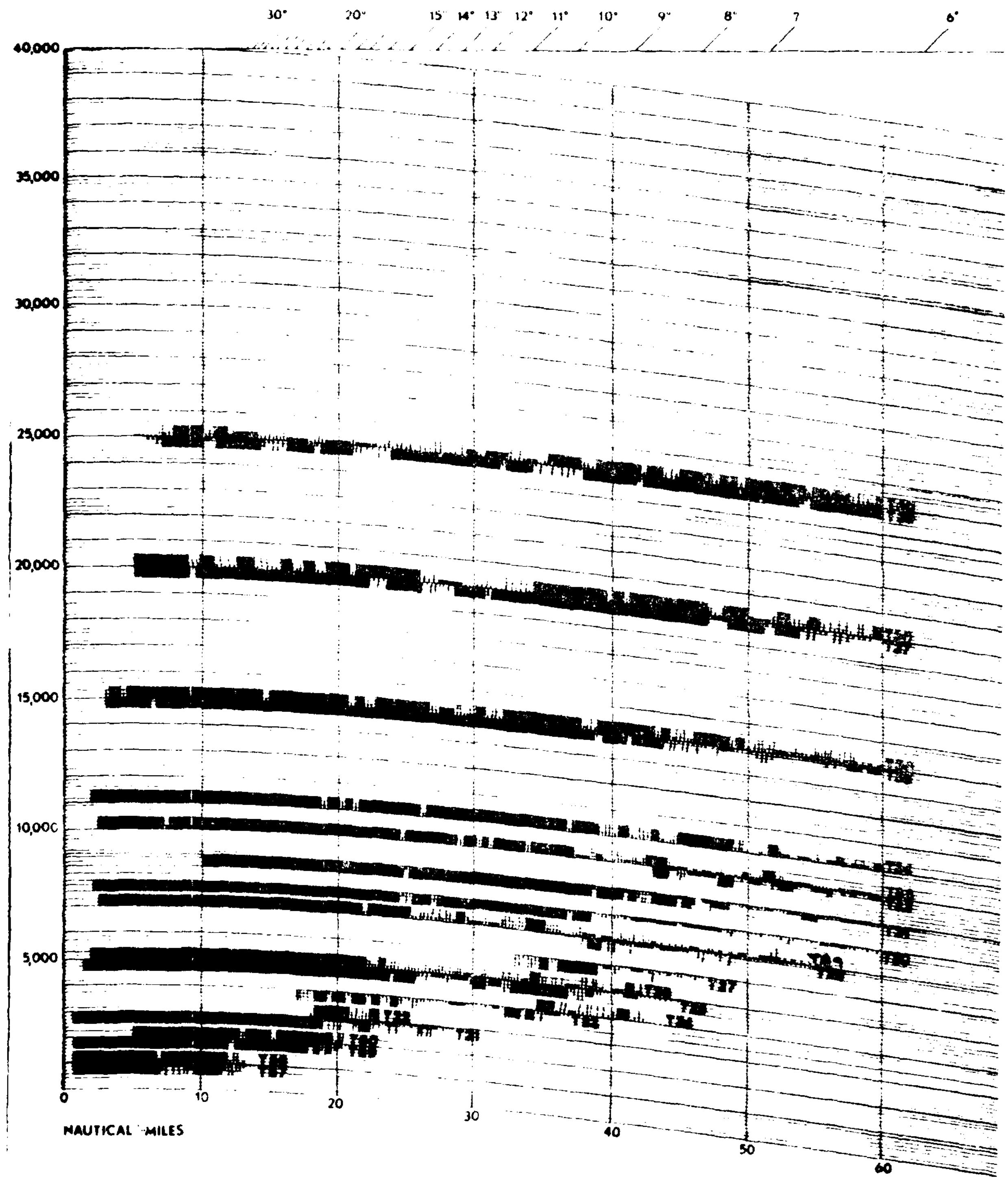
TRACK NO.	TIME (L)	ALT ABOV. FIELD AGL	ASPECT	MECH TILT	SELECTIBLE FEATURES	DETECTION RANGE		REF RANGE NM	DIF FROM REFERENCE		OUTER RNG AZIMUTH	TRACKING							ATCRBS		REMARKS
												WITHIN MTI		OUTSIDE MTI		OVERALL		QUALITY	BSR %	OUTER RANGE	
						INNER	OUTER		NM	dB		ATS	BSR	ATS	BSR	ATS	BSR				
VERTICAL PROFILE																					
17	0900	1000	A	2.0	C,B,G	0	9				045	2.68	92			2.68	92	C			NOTE 3
18	0906	1000	F	2.0	C,B,G	0	8				045	2.65	91			2.65	91	C			NOTE 3
19	0911	2000	A	2.0	C,B,G	0	20				045	2.71	91			2.71	91	C			NOTE 3
20	0920	2000	F	2.0	C,B,G	0	14				045	2.87	97			2.87	97	C			NOTE 3
57	1340	1000	A	2.0	C,A,G	0.5	13	12	+1		045	2.78	94			2.78	94	C			NOTE 1
58	1346	1000	F	2.0	C,A,G	0.5	13	12	+1		045	2.89	96			2.89	96	C			NOTE 1
59	1351	2000	A	2.0	C,A,G	0.5	20	18	+2		045	2.92	97			2.92	97	C			NOTE 1
60	1400	2000	F	2.0	C,A,G		20.5	18	+2.5		045	2.92	97			2.92	97	C			NOTE 1
21	0926	3000	A	2.0	C,B,G	0.25	26	26	0		045	2.59	85			2.59	85	C			NOTE 1
22	0932	3000	F	2.0	C,B,G		23	26	-3		045	2.60	87			2.60	87	C			NOTE 1
23	0940	4000	A	2.0	C,B,G		35	35	0		045	1.91	57	1.68	47	1.85	54	C			NOTE 1
24	0950	5000	A	2.0	C,B,G		41	39	+2		045			2.10	66			C			
25	0955	5000	F	2.0	C,B,G		39	39	0		045	2.64	86	1.54	44	2.37	76	C			
26	1008	5000	A	2.0	B,G	1.5	39	39	0		045	2.76	90	2.67	97	2.74	92	C			
27	1026	6000	A	2.0	C,B,G		39	40	+1		045			2.65	87	2.65	87	C			
28	1037	7000	A	2.0	C,B,G		40	42	-2		045			2.30	80	2.30	80	C			
29	1043	7000	F	2.0	C,B,G	2.5	37	42	-5		045	2.80	92	2.14	83	2.04	90	C			
30	1100	8000	A	2.0	C,B,G	2.0	38	43	-5		045	2.95	98	2.94	97	2.95	98	C			
31	1406	9000	A	2.0	C,B,G		48	44	+4		045	2.97	98	2.61	87	2.79	93	C			
32	1422	10000	A	2.0	C,B,G		53	47	-6		045			1.57	49	1.57	49	C			
33	1116	10000	F	2.0	C,B,G		52	47	-5		045	2.96	99	1.98	62	2.54	83	C			
34	1431	10000	F	2.0	B,G	2.0	59	52	+7		045	2.96	99	2.17	69	2.57	84	C			
35	1453	15000	A	2.0	C,B,G	3.0	60	53	+7		045	2.97	99	2.02	66	2.49	82	C			
36	1509	15000	F	2.0	C,B,G	3.0	57	53	+4		045	2.83	96	2.14	81	2.66	88	C			
37	1530	20000	A	2.0	C,B,G	5.0	56	57	-1		045	2.79	92	2.67	84	2.73	88	C			
38	1540	20000	F	2.0	C,B,G	5.0	60	57	+3		045	2.38	75	2.42	78	2.40	77	C			
39	1554	25000	A	2.0	C,B,G	6.0	60	60	0		045	2.54	83	2.71	92	2.63	88	C			
40	1606	25000	F	2.0	C,B,G	7.0	60	60	0		045	1.75	57	2.58	88	2.21	74	C			

AFCS FORM SEP 77 918 PREVIOUS EDITION IS OBSOLETE.

VERTICAL PROFILE COVERAGE CHART

Nellis AFB

January 1980



REMARKS

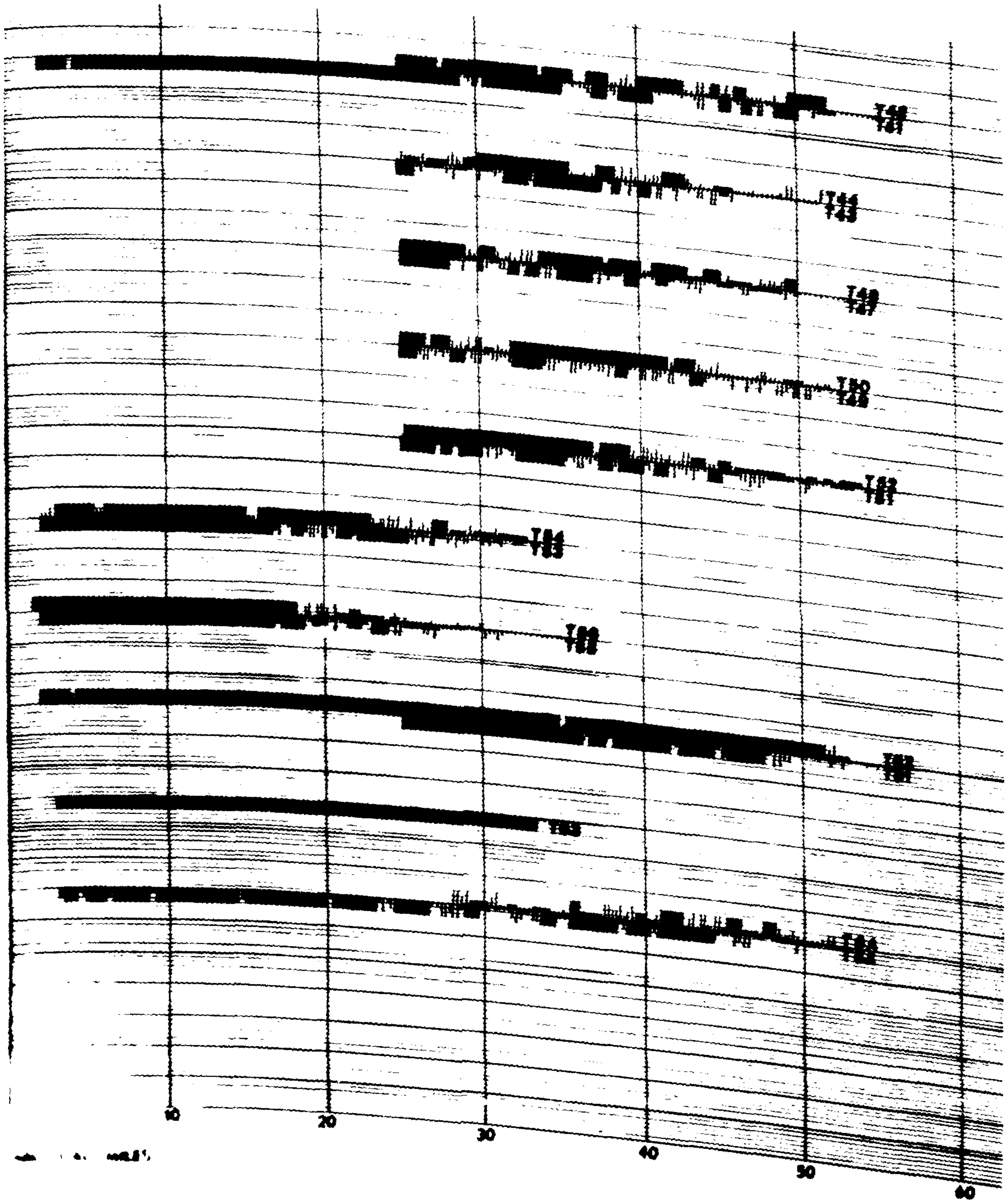
All tracks were flown on the Nellis 045 radial.

DETECTION/TRACKING DATA												*LEGEND:* SEE ATTACHMENT A21-8									
1. LOCATION: Nellis AFB						2. TYPE RADAR: AN/GPN-20						3. MTI GATE: 045 at 32NM; 255 at 37.5NM				4. TYPE AIRCRAFT: C-140			5. DATE: January 1980		
TRACK NO	TIME (L)	ALT ABOV FIELD AGL	ASPECT	MECH TILT	SELECTIBLE FEATURES	DETECTION RANGE		REF RANGE NM	DIF FROM REFERENCE		OUTER RNG AZIMUTH	TRACKING							ATCRBS		REMARKS
												WITHIN MTI		OUTSIDE MTI		OVERALL		QUALITY	BSR %	OUTER RANGE	
						INNER	OUTER		NM	dB		ATS	BSR	ATS	BSR	ATS	BSR				
FEATURE COMPARISON																					
41	1048	6500	A	2.0	EBDG	2.0	50.5	47	+3.5		045	2.92	97	2.10	67	2.60	85	C			
42	1106	6500	F	2.0	EBDG	25	52	47	+5.0		045	2.88	94	2.38	75	2.47	78	C			
43	1120	6500	A	2.0	B,F,G	25	44	47	-3.0		045	1.55	35	2.40	69	2.18	65	C			
44	1123	6500	F	2.0	B,F,G	25	44	47	-3.0		045	1.44	44	2.22	73	2.00	65	C			
47	1132	6500	A	2.0	B,G	25	43	47	-4.0		045	2.37	68	2.06	63	2.15	64	C			
48	1145	6500	F	2.0	B,G	25	50	47	+3.0		045	2.82	94	2.29	73	2.39	77	C			NOTE 1
49	1152	6500	A	2.0	B,C,G	25	50.5	41	+9.5		045	2.32	79	1.83	57	1.93	62	C			NOTE 1
50	1209	6500	F	2.0	B,C,G	25	45	41	+4.0		045	2.45	80	2.66	87	2.60	85	C			
51	1214	6500	A	2.0	BGKE	25	48	47	+1.0		045	2.80	90	2.22	72	2.35	76	C			
52	1225	6500	F	2.0	BGKE	25	45	47	+2.0		045	2.83	94	2.56	87	2.63	89	C			
61	1235	6500	A	2.0	BDGK	25	49	47	+2.0		045	3.00	100	2.83	93	2.86	94	A			NOTE 1
62	1245	6500	F	2.0	B,G,K	2.0	52	47	+5.0		045	2.99	100	2.95	99	2.97	99	A			NOTE 1
63	1257	10600	A	2.0	B,G,K	3.0	34	33	+1.0		255	3.00	100	3.00	100	3.00	100	A			NOTE 1
53	0830	10600	A	2.0	EBGDK	2.0	30	33	-3.0		255	2.68	89			2.68	89	C			NOTE 1
54	0842	10600	F	2.0	EBCK	2.0	28.5	33	-4.5		255	2.75	87			2.75	87	C			NOTE 1
55	0850	6500	A	2.0	B,G,K	2.0	27	27	0.0		045	2.67	88			2.67	88	C			
56	0914	6500	F	2.0	B,G,K	1.5	21	27	-6.0		045	2.82	94			2.82	94	C			

TITLE

FEATURE COMPARISON COVERAGE CHART

LOCATION	DATE
Nellis AFB	January 1980



LEGEND:

SELECTIBLE FEATURES	QUALITY	ASPECT
A – A CHANNEL SELECTED B – B CHANNEL SELECTED C – CIRCULAR POLARIZER SELECTDE (LINEAR POLARIZATION SELECTED IN ALL OTHER CASES) D – PROCESSOR (MPN–SERIES), ENHANCER (GPN–12), INTEGRATOR (FPN–47) SELECTED E – STC (FOR GPN–12 E IS FOLLOWED BY 2, 3, 4 TO DENOTE WHICH STC USED OTHER THAN STC–1 SELECTED F – FTC (MPN–SERIES NOT MODIFIED WITH LOG RECEIVERS) LOG FTC SELECTED G – STAGGER PRF SELECTED H – PWD SELECTED J – WEATHER BACKGROUND K – OTHER (NOTE IN REMARKS) NOTE 4	A – NO HOLES B – HOLE/OUTSIDE MISSION AREA C – MULTI–HOLES/OUTSIDE MISSION AREA D – HOLE/WITHIN MISSION AREA	F – FRONT A – AFT B – BROADSIDE V – VARIABLE

REMARKS *(Continued)*

NOTE 1: Screened

NOTE 2: Track flown inbound to 30 NM to verify outer range.

NOTE 3: Flown to verify beam splitting coverage.

NOTE 4: Track 51 and 52 dual diversity; track 53,54,55, and 56 is passive beam; track 61,62, and 63 dual diversity and passive beam.

TITLE

REFRACTIVE THEORY AND DEFINITIONS

1. The bending or refraction of electromagnetic energy as it passes through the air occurs because of the structure of the troposphere. Energy propagated through a vacuum would travel in a straight line. Similarly, energy transmitted through any gas (or liquid) that is uniform in density perpendicular to the direction in which the energy is traveling, will follow a straight line path. However, due to the physical characteristics of the troposphere, the density of the troposphere decreases with increasing height. Therefore, the front of energy transmitted at low elevation angles will be subject to refractive bending. Usually, the top of the wave front will move faster than the bottom, since the density of the atmosphere decreases with height. The result is a downward bending of the transmitted energy.

2. The number that describes the relative speed of propagation in any substance is referred to as the index of refraction (n). It is defined as the ratio of the speed of propagation of electromagnetic energy in a vacuum (c) to the speed of propagation of electromagnetic energy in the medium in question (v):

$$n = \frac{c}{v}$$

Within the wavelength band from 1 cm (30 GHz) to 10 meters (30 MHz), the index of refraction does not change appreciably as the frequency changes. The typical range of values of n at sea level is from 1.000250 to 1.000450. Since these numbers are difficult to work with, a "scaled-up" quantity called refractivity (N) is used, and is defined as

$$N = (n - 1)\,10^6$$

Thus the range of values of refractivity at sea level becomes 250 to 450 N-units.

3. As mentioned earlier, the bending of energy is caused by the change in density with height in the air. Since the speed of propagation of energy is related to the density of the air, and the refractivity (N) is related to the speed of propagation of energy (by definition), then refractivity in the troposphere is directly related to the density of the air. Therefore, the bending of electromagnetic energy may be thought of as due to the change of refractivity with height in the troposphere, or the vertical gradient of refractivity. It is important to note that it is not the value of N at a particular point that determines refraction but it is the gradient of refractivity that must be considered. The refractivity may be related to the meterorological variables of pressure (p), temperature (T), and water vapor pressure (e) by the following equation:

$$N = \frac{Ap}{T} + \frac{Be}{T^2}$$

where A and B are constants. The normal rapid decrease of p and e with height in the troposphere leads to a decrease of N with height. Temperature usually decreases slowly with height, and this has an opposite effect on the change of N. In the so-called "standard" atmosphere, the result is that N will decrease by about 12 N-units per 1000 feet of altitude through the lower levels of the troposphere, and 6 N-units per 1000 feet in the upper levels. It is this decrease of refractivity with height that leads to the "normal" downward curvature, or refraction, of electromagnetic energy.

TITLE

REFRACTIVE THEORY AND DEFINITIONS

4. In the "real" troposphere all is not so simple. The temperature and water vapor pressure may vary in any manner, while atmospheric pressure will continue to decrease with height. This seemingly random variation of the meteorological terms will lead to unusual changes in refractivity with height. Refractivity may decrease more than in the "standard" troposphere, causing more pronounced bending of electromagnetic energy. On the other hand, refractivity may actually increase with height, which may result in an upward curvature of a radio/radar beam (opposite the curvature of the earth). The propagation of electromagnetic energy along a path that is different from the usual or expected path is known as "anomalous propagation" (AP). The refraction that results under various AP conditions is referred to as either subrefraction, superrefraction, or trapping (ducting). These refractive conditions, the effects on electromagnetic energy presented as a single ray, and the gradients of refractivity that may cause them are defined below:

a. Subrefraction: Ray curvature is upward. Radio/radar ranges are significantly reduced. The occurrence is quite rare. The gradient of refractivity is equal to or greater than 0 N-units/1000 feet (average "standard" value is - 12 N-units/1000 feet).

b. Normal refraction: Ray curvature is downward but not as much as the curvature of the earth. Radio/radar performance is generally undisturbed, and the occurrence is frequent. The gradient of refractivity is less than 0 N-units/1000 feet and greater than - 24 N-units/1000 feet.

c. Superrefraction: Ray curvature is downward, more sharply than normal, but not as much as the curvature of the earth's surface. Radio/radar ranges may be significantly extended; the occurrence is frequent. The gradient of refractivity is greater than -48 N-units/1000 feet and less than or equal to -24 N-units/1000 feet.

d. Trapping: Extreme superrefraction, with downward curvature equal to or greater than the curvature of the earth's surface. Radio/radar performance is greatly disturbed, ranges are greatly extended, holes in coverage may appear; occurrence is not normally frequent. The gradient of refractivity is less than or equal to -48 N-units/1000 feet.

5. For an understanding of refractive effects on the system being evaluated, refer to AFCS Pamphlet 100-79.

INTRODUCTION TO THE RADAR COVERAGE INDICATOR

1. General: The RCI graphically portrays the vertical coverage of a radar and is one of the basic tools used as a standard to predict radar detection performance. Except for an allowance for standard refraction, the RCI is a free-space portrayal. It is made more applicable to a particular radar by applying unambiguous range limits (PRF limits) and true antenna tilt.

2. RCI Composition: The RCI consists of two parts, a background and a modified antenna coverage pattern.

a. Background: The background serves as the base of the RCI and provides the coordinates of range, antenna tilt angle, and aircraft altitude. The background displays different ranges as arcs centered at the antenna focal point and extended to 70 NM. Antenna tilt angles are marked around the edge of the background from 1.5° below to 20° above horizontal. Aircraft altitudes are depicted from the antenna focal point up to 40,000 feet AGL.

b. Modified Antenna Coverage Pattern: The modified antenna coverage pattern shows boundaries of constant signal returns and is referenced to the aircraft radar profile. The lobes are identified by alphabetical letters which are referenced to individual aircraft in Attachment 23-6. The point on the RCI where the altitude on an particular aircraft intersects the lobe that represents the aircraft's reflectivity size is the predicted radar reference range.

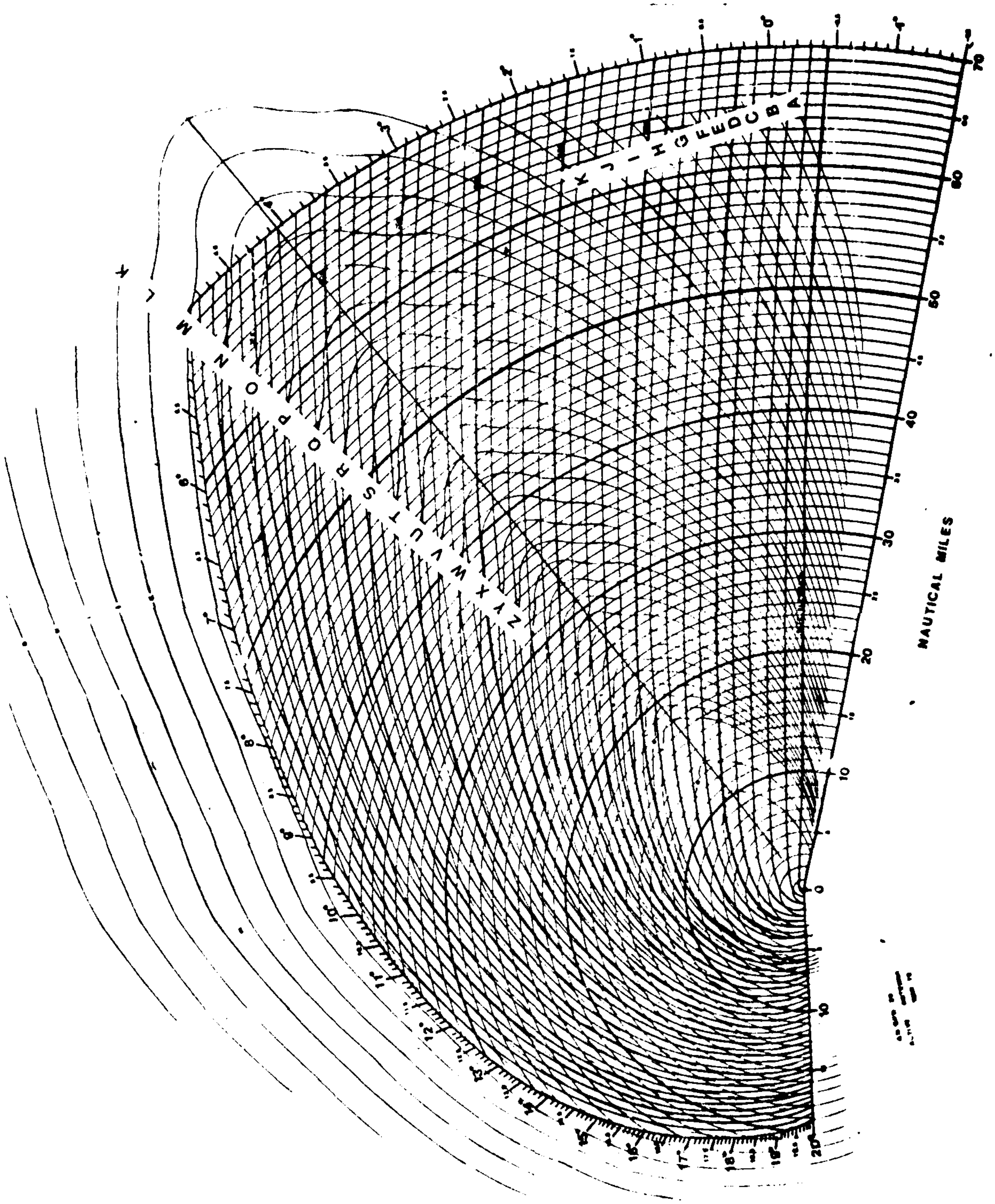
3. Actual Versus Predicted Maximum Range: The outer fringe of the radar may be determined using targets of opportunity, or if possible, a dedicated aircraft. Only aircraft of known reflectivity and altitude can be used as valid targets. Maximum range samples must be taken with the integrator off and LP selected. The RCI was constructed for a single-scan probability of detection of 50 percent; therefore, the range at which 50 percent useable targets are achieved is the comparison point. The 50 percent range is the midpoint of the outermost 10 scan cell containing at least five useable targets. To find this point one should start at the outermost usable target and count 10 scans back from it. Slide the 10 scan cell back in one-scan increments until the 50 percent point is reached. Useable targets are defined in paragraph 215.3 of AFM 55-8.

4. Conclusion: The RCI in Attachments A23-2/5 has been set for the true antenna tilt determined during the evaluation and is ready for use. It should be emphasized that the RCI is only a theoretical prediction tool, and data obtained using this tool are not absolute and can be quite variable. Only after several samples are taken and a definite trend developed should any corrective actions be contemplated.

TITLE

RCI (ACTIVE)

LOCATION	DATE
Nellis AFB	January 1980



REMARKS

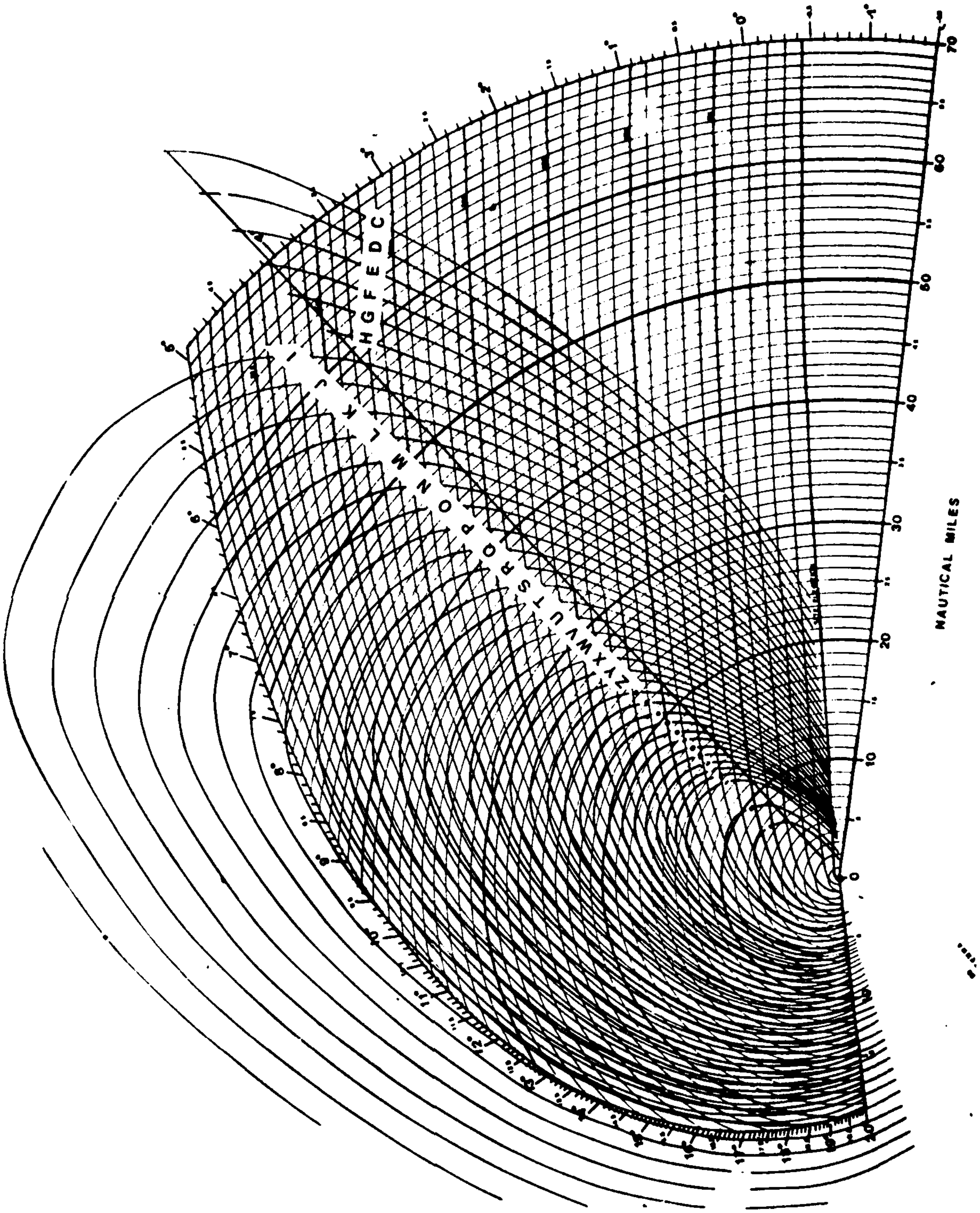
78-50781

TITLE

RCI (PASSIVE)

LOCATION: Nellis AFB

DATE: January 1980



REMARKS

TITLE

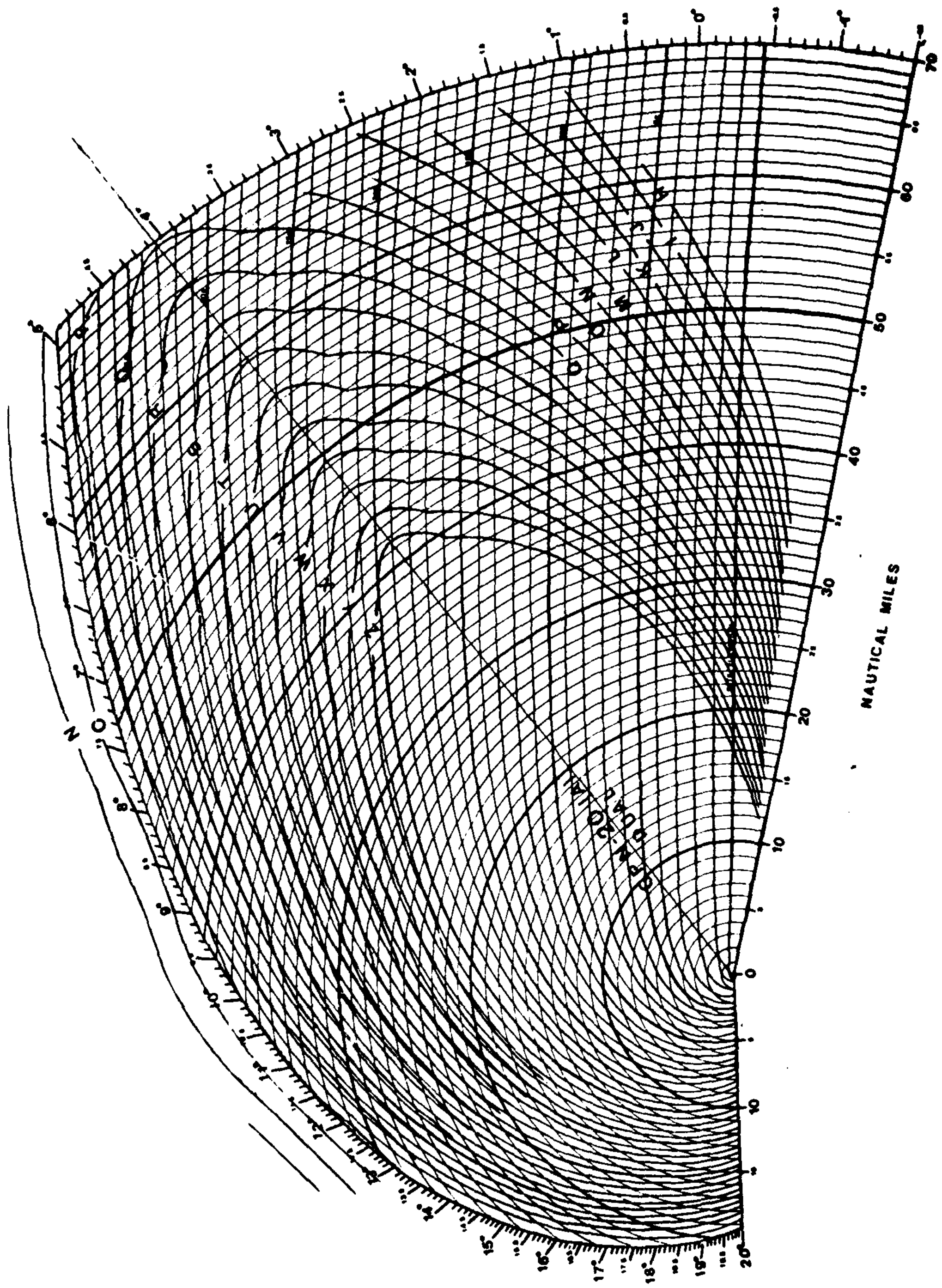
RCI DUAL (ACTIVE)

LOCATION

Nellis AFB

DATE

January 1980

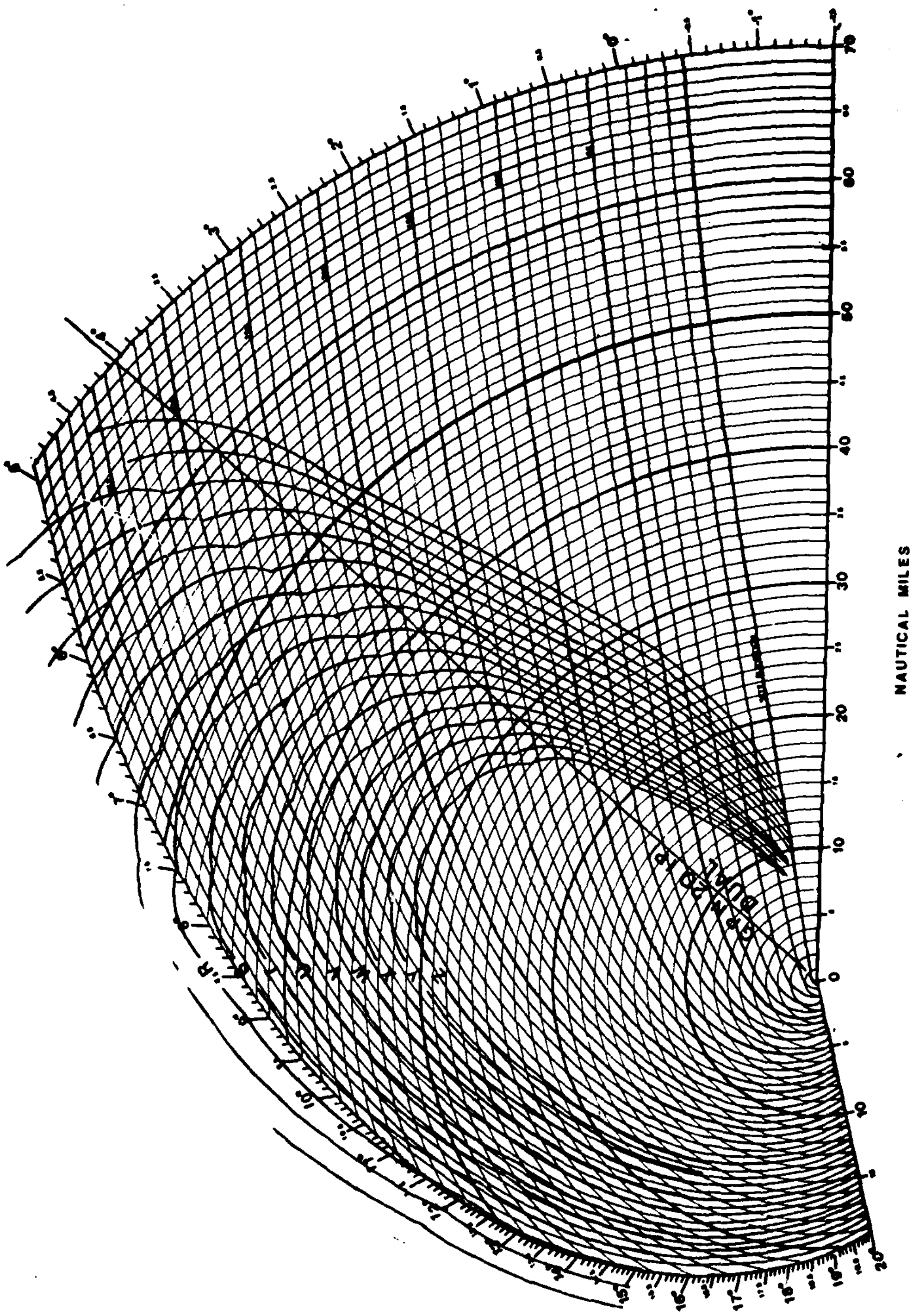


REMARKS

TITLE

RCI DUAL (PASSIVE)

LOCATION	DATE
Nellis AFB	January 1980



REMARKS

AIRCRAFT REFLECTIVITY

TYPE AIRCRAFT	REFLECTIVITY	TYPE AIRCRAFT	REFLECTIVITY
A-1G	J	CONVAIR 990	E
A-3B	I	F-4C	J
A-4F	N	F-5A	O
A-6A	K	F-8E	L
A-10	K	F-14	I
AERO CMDR	M	F-15	J
B-52	D	F-16	M
B-57B	J	F-100	L
B-66B	I	F-101B	J
BEECH BARON	O	F-102	K
BEECH BONANZA	S	F-104	M
BOEING 707	E	F-105	K
BOEING 720	F	F-106A	J
BOEING 727	F	F-111A	N
BOEING 737	H	GRUMMAN GOOSE	L
BOEING 747	Y'	GRUMMAN GULFSTREAM	J
BRITANIA	F	LEAR JET	O
C-5	Y'	0-1	T
C-45	L	0-2	Q
C-47	G	0V-1	K
C-54G	C	0V-10	L
C-123	D	T-28	L
C-130	A	T-33	N
C-131	D	T-34	R
C-133	W'	T-37	P
C-135	E	T-38	O
C-140	M	T-39	N
C-141	E	U-2	M
CESSNA 336	Q	U-3B	O
CONVAIR 440	D	U-6	P
CONVAIR 880	F	U-8	N